1991

Toward the optimization of cell operator productivity in computer integrated manufacturing

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Order Number 9131188

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University of Northern Iowa, 1991

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TOWARD THE OPTIMIZATION OF CELL OPERATOR

PRODUCTIVITY IN COMPUTER INTEGRATED MANUFACTURING

A Dissertation

Submitted in Partial Fulfillment

of the Requirements for the Degree

Doctor of Industrial Technology

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May 1991

DEDICATION

This research is dedicated to

the memory of my father,

Leonard Joseph Gobeski

and to all those

machinists, cell operators, and manufacturing engineers

laboring in the vineyard

ACKNOWLEDGEMENTS

Beyond the content and its conceptual origins, there lies the need for direction, correction, and high expectations. I appreciate the time, effort, and consideration provided by all of my committee members: Dr. Ervin A. Dennis (major advisor and professor), Dr. Douglas T. Pine (coadvisor), Dr. Charles V. L. Dedrick, Dr. Harley E. Erickson, Dr. Mohammed Fahmy, and Dr. Taggart F. Frost. Dr. Dennis provided much help in the overall management of this study and the process of refining it. Indeed, he took on much of the physical aspects such as distributing the dissertation drafts and meeting with other committee members that often are the responsibility of the candidate. I am very grateful for his appreciating the difficulty that distance added to the dissertation process. I was often tempted to ask him for such indulgences, but he always perceived my need ahead of me and offered his help. His empathy was and is great.

Dr. Pine's suggestions and commentary kept the language and direction oriented toward the operators and engineers who will hopefully find this dissertation useful. His suggestions in broadening the research base were very useful and fruitful. Dr. Fahmy and Dr. Dedrick offered scrupulous suggestions that facilitated reflection on the subject matter and readability. Dr. Erickson's attention to the minutest details and logical flow has helped keep this document together as a holistic and worthwhile endeavor.

A special "thank you" is offered to Dr. Frost who not only provided significant editorial commentary, but he also kept this effort from foundering on the "rocks" of amateurism and lack of credibility throughout the proposal and dissertation phases by his timely, well-directed, and very substantial suggestions. As a result, this dissertation should provide some direction in finding the "cures" for the "people" problems of manufacturing.

I thank Mrs. Barbara Kueter for her suggestions and guidance in assuring compliance with the publication format.

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CHAPTER 1

INTRODUCTION

Stanton (1982) considered low worker productivity to be the most worrisome problem facing American business. Some experts (Staff, 1987) viewed technological implementation of computer integrated manufacturing (CIM), the use of computers to tie together all functions in a manufacturing enterprise, as the solution to the productivity problem. However, several studies have shown that personnel problems with CIM have been responsible for CIM failures (Criswell, 1988). Costello (1989, p. 3) found that "human systems comprise the most critical asset for manufacturers." Thus, the emphasis in CIM has been changing. Beckert, Knill, Pascarella, and Weimer (1989) believed it was more important to study the management and utilization of technologies than to study the specific technologies. "Ultimately, it's people--not technology--who will realize the exciting potential of CIM" (Ciampa, 1987, p. 20).

With a reemphasis on people in CIM, work cells have been receiving more attention. Flexible manufacturing systems (FMS) have been more closely examined with just-in-time (JIT) being used as the measure of system flexibility (Krag, 1988). Also, to "continuously improve human capabilities," has been one factor needed in measuring system flexibility according to Krag (p. 2). Nisanci (1989) stated that omitting the human factors could doom JIT to failure. Industrialists have begun to realize that success may be found in utilizing human resources.

Focusing on People

Of those examining the use of people respecting CIM, the following perspectives were revealed: (a) human operators directly controlling CIM have added more efficiency, flexibility, and economical factors to CIM (Staff, 1986), (b) system enhancement has resulted when those using the system understood the limitations and capabilities of the system (Criswell, 1988), and (c) profitability has increased when the human resource issues at every stage of system development and implementation were understood and addressed (Paris, 1988). In looking toward the future, fifth generation management (FGM) has been the expected approach for controlling CIM. As FGM has required managers to post information to the electronic bulletin boards and to have utilized information posted to such boards through a system of assumed responsibilities, it has become very clear that operators, specifically responsible operators, have been needed in FGM/CIM. Thus, CIM has utilized people as opposed to the elimination of people through automation (Savage, 1989).

There has been the argument that the eventual resultant would be the "unattended" factory. That has been envisioned as the ultimate realization of robotics and CIM. With such an outcome considered highly probable, human considerations would have to appear as transient phenomena which would have to be endured until the systems "mature." However, a serious problem has appeared. It seems to have no resolution and it has made the unattended factory improbable. Posed as a question, the problem has been: How are unexpected, unforeseen problems dealt with in computerized systems? A positive answer has been that the computerized system has been implemented with all possible alternatives and scenarios. Of course, the implementation has been initiated by people. So, all that has remained has been to know all of the conditions under which the system operated. It has become obvious that there has been no positive answer because human fallibility has made knowing everything about anything impossible. Thus, people with all their fallibilities have been necessary for the successful operation of any human-made system. Simply put, people have always been needed to detect the mistakes and correct the errors in CIM (Bourne & Wright, 1987; Criswell, 1988). According to Welter (1986), "Our factories are not unmanned factories and will not be in the foreseeable future" (p. 18).

The Need to Identify Cell Operator Motivating Factors

With the realization that people have been essential to CIM success, it has been relevant to consider the impacts of new technologies on people. According to Beckert et al. (1989), "Labor will always be the key to production success, experts say. But the nature of that labor, the relationship between technolgical [sic] capital and human capital, is going to evolve quickly into a brave new world" (p. IM16). Traditional approaches to obtaining and utilizing people have not been effective in developing "human capital" (Williamson, 1989). People have behaved differently even in roles they have held for years (Ciampa, 1987). Thus, it appears that workers no longer have stable references in defining their work. This has lead to uncertain worker expectations if, as Peter Drucker (1973) believed, a person defined his or her self by his or her work. Jobs have been changing and people have been changing and both have been changing rapidly. Reflecting on the expectations of workers has been an important endeavor. According to Welter (1986), perhaps the worker has been owed the consideration of how CIM has affected or can affect his or her work.

The cell operator role has been one manifestation of technological change and the role has been a resultant of the mutual impacts of technological capital and human capital. Examination of that role and its tasks has been expected to provide insight into the mechanisms of technological change and its impacts. The cell operator has been thrust into a critical position as fewer people have been needed on the plant floor and those who have remained have assumed more responsibility for the product and/or processing (Paris, 1988). Due to the interlocking nature of the component subsystems in CIM, specifically FMS, "a malfunction in any part of the production process has quicker, graver and more costly consequences for the whole system in an integrated factory" (Paris, p. 2). Concerning expensive complex systems, Criswell (1988) emphasized: If anticipated levels of up-time and quality are to be achieved, it would be necessary to maintain high levels of commitment and motivation. For some (Hobson, Gill, & Gill, 1988;

Blanchard, 1988) motivation has been more important than skill. Thus, motivation may have assumed a critical role for the cell operator whose job has appeared to be very stressful while the job has required more attentiveness.

In summary, there have been three notable points that demonstrate the importance of examining the cell operator. First, it has been seen that roles and tasks of the operators are changing rapidly. The cell operator has typified these rapid role and task changes. Second, the operator, specifically the cell operator, has been viewed as an important, indeed, critical component of CIM. Finally, motivation of the operator has required serious consideration. Currently, there is no information available that has stated or that has suggested what has motivated cell operators on the job. As the three points have indicated the importance of knowing what motivates the cell operator, there has been a great need for information that reveals cell operator motivating factors.

The Need to Involve Manufacturing Engineers

As soon as information has become available on factors in cell operator motivation, the most important consideration should have been focused on how the information could be more effectively utilized. Consequently, there is the necessity of establishing some methodology that assures or that attempts to assure that motivated operators would be the eventual resultant of the information collected. That is, the information collected must have practical applications. It has appeared that the manufacturing engineers have been in the position of implementing job designs that facilitate the motivation of the cell operators. Engineers do this by providing job enrichment, those factors of work motivation that make a person want to do his or her job well.

Optimum technological systems have not been realized because the systems have deteriorated in the "handoff" from the designers of the technologies to the users of the technologies (Beckert et al., 1989). Zylstra (1987) stated that the "wall" between manufacturing and engineering would have to be broken down such that proaction for engineering change could result. This meant that manufacturing engineers and production supervisors have needed to cooperate in making changes. However, Williamson (1989) indicates "in-plant experiences have shown that the first-line supervisors are the weakest link in changing workplace practices" (p. 14).

According to Criswell (1988), in an effective use of CIM, operators and engineers need to get together in the development lab where the operator can assist the engineer in evaluating and designing equipment (Criswell, 1988). Ideally, computer-based changes could be made by plant-floor workers and factory engineers without having to involve computer professionals (Larin, 1989). Consequently, there is a strong argument for increasing direct contact between manufacturing engineers and cell operators to implement effective job changes. It has been noted by Hatch and Kruppa (1989) that, by the year 2000, "production workers will be consulted as a matter of course on the structuring of any new jobs or the changing of existing jobs in at least 30% of U.S. industry" (p. 12).

Purposes

There were two purposes in conducting this study. One purpose was to identify the factors that motivate cell operators. Henceforth, those factors will also be referred to as elements of job enrichment as job enrichment is the motivational component of job design which is added by manufacturing engineers. Having reflected upon the importance of the operator in CIM and the value of motivating the operator, satisfying such a purpose should contribute substantially to operator productivity. Also, it has been anticipated that an investigation into cell operator motivation would strongly encourage the manufacturing engineer to gain a better knowledge of cell operator motivation. This might result, through the engineer's design or redesign of the cell operator's working environment, in optimizing the productivity of the cell operator. The second purpose of this investigation was to demonstrate to manufacturing engineers that considerations of elements of job enrichment in the cell operator's job play an essential role in cell design.

In previous research (Kovach, 1987; Hoh, 1980; Kovach, 1980; Harris, 1976), it was found that foremen were not knowledgeable of job expectations held by their subordinates. Yet, foremen usually come from the ranks of subordinates. Manufacturing engineers do not usually progress from production worker positions to engineering positions. Thus, if foremen were unable to predict the expectations and job desires of their subordinates, then it is deduced that manufacturing engineers would have been even less likely to predict the job expectations and desires of cell operators. As a result, it is possible that current cell design activity has been insufficient in facilitating cell operator motivation. That is, cell design has evolved without consideration of the operator's perceived needs and this factor may have negated the advantages of incorporating CIM. If motivation has been as important as opinions make it appear to be, then there may be a serious problem. It seems then, that there is a great need to identify elements of job enrichment that motivate cell operators, as well as an urgency to strongly encourage manufacturing engineers to utilize this information in designing cells.

Problems

In this study, three problems were examined. The first problem was determining elements of job enrichment for the cell operator and the level of importance of the elements to the cell operators. As an extensive review of the literature revealed no studies dealing with cell operator motivation, information on cell operator elements of job enrichment would have to be gathered from the operators. The second problem was determining the predictions of manufacturing engineers of the importance of the elements of job enrichment to cell operators. The third problem of the study was determining if there were significant differences between the views of the operators and the engineers regarding the elements and their levels of importance.

The research questions that follow were one result of the literature review. Specifically, the motivating factors used in previous research were examined to determine which factors would be most appropriate for use in this study. It is emphasized that no previous literature exists that examines cell operator motivation. The methodology provided later solves the problems of obtaining and comparing operators' and engineers' responses while examining those responses for significant differences. Also, within the literature review, the job motivation base was examined and presented with an emphasis on what was relevant and useful to the technologist. This approach provided the engineers with a reference that could help satisfy their need for such information in incorporating motivating factors into cell designs.

Research Questions

The following research questions were investigated to determine if there were significant differences between cell operators and manufacturing engineers in their perceptions of how much the cell operators needed job enrichment. The elements of job enrichment were identified by the research questions. The research questions follow as closely as possible the actual wording of items on the data collection instruments after the phrase "Do cell operators and manufacturing engineers differ in their ratings of the cell operator's____ ."

Research Question 1

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for high respect and fair treatment from his or her supervisor?

Research Question 2

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for stimulating and challenging work?

Research Question 3

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for chances to exercise independent thought and action in his or her job?

Research Question 4

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for great job security?

Research Question 5

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for very friendly coworkers?

Research Question 6

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for opportunities to learn new things from his or her work?

Research Question 7

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for high salary and good fringe benefits?

Research Question 8

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for opportunities to be creative and imaginative in his or her work?

Research Question 9

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for quick promotion?

Research Question 10

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for opportunities for personal growth and development in his or her job?

Research Question 11

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's desire for a sense of worthwhile accomplishment in his or her work?

Research Question 12

Do cell operators and manufacturing engineers differ in their ratings of the cell operator's would like growth needs strength (WLGNS)?

Research Question 13

Do cell operators and bench workers differ in their ratings of WLGNS?

Limitations

The following limitations have resulted from the need to consider the practical aspects of the survey environment. The limitations are of two types. One type is that imposed by the researcher because of resource restrictions which is often called a delimitation. The second type is that imposed upon the researcher by the nature of the study which is often called a limitation. This study makes no specific distinctions in categorizing between the two types.

Limitation 1

The lack of financial resources was the biggest limitation of this study. The primary result of this limitation was the restricting of data collection regarding the number and use of mailed questionnaires. In having reflected upon other data collection techniques, using any type of interviewing and/or telephone surveying, such consideration was moot respecting this study.

Limitation 2

Time was severely restricted, having been limited by professional considerations to Summer, 1990. This had put interviewing as a data collection technique in double jeopardy.

Limitation 3

Because of the difficulty in locating an acceptable population of cell operators, it was necessary to purchase a mailing list from a magazine publisher. To limit variance in comparing results between cell operators and manufacturing engineers, the engineer mailing list was also purchased from the same publisher. Thus, all subjects were limited to the combined list of subscribers of Modern Machine Shop and Production magazines.

Limitation 4

There were only 332 subjects available from the subscription lists who could fit the description of cell operators. Assumption 2 was necessary in preventing this limitation from further limiting the generalization of results based on operator responses.

Limitation 5

Two restrictions were used to reduce the engineering group before random sampling was employed. The first restriction was that the engineers were employed at sites of 1000 or more employees. The second restriction was that their employers produced goods under Standard Industrial Classification (SIC) codes of 3500 through 3599 and 3700 through 3799 (Henceforth, referred to as 35 and 37).

Limitation 6

The variations of the survey instruments used, the Job Diagnostic Survey (RJDS) and the Job Rating Form (RJRF), also limited the accuracy of results. The developers of the original instruments, J.

Richard Hackman and Greg R. Oldham (1980) stated that the instruments have their faults, but the instruments are probably better than any other instruments available for collecting this type of job enrichment data.

Assumptions

In conducting a useful study, the following assumptions were necessary. Most assumptions are a response to the limitations in preventing the latter from diminishing the value of results.

Assumption 1

The populations surveyed were considered unimodal and symmetrical. There were no requirements for subscribing to Modern Machine Shop and Production that would have caused any subset of subjects in either group of cell operators or manufacturing engineers to have constituted a skewed or polarized distribution.

Assumption 2

The population of cell operators surveyed that read Modern Machine Shop and/or Production magazines was a representative sample of the population of all cell operators.

Assumption 3

The sample of manufacturing engineers, though limited by employer size and SIC codes, was typical of engineers involved with CIM.

Assumption 4

Though geographic and economic tendencies resulted from restricting the engineering group surveyed, the sample surveyed was representative of the universal group of manufacturing engineers involved with CIM.

Assumption 5

Respondent self-report was facilitated by the use of Likert scales which made it likely that the respondents provided correct numerical responses associated with their feelings. Thus, respondent self-report was reasonably accurate.

Assumption 6

Those who responded to the surveys were those to whom the mail was addressed even though it was possible for someone other than an addressed recipient to reply.

Assumption 7

Working conditions such as excessive noise or poor lighting attending the act of responding did not unduly affect the responses.

Assumption 8

Respondents replied truthfully. It was hoped that the importance of this study and the promise of higher productivity that it offered would impress respondents with the need for truthfulness.

Assumption 9

Results were generalizable to all discrete manufacturing. The SIC codes used to restrict the choosing of subjects for the engineering group are specific to discrete manufacturing.

Assumption 10

The numerical data derived from the Likert scale were treated as interval scale continuous data. This assumption allowed for treating responses statistically in determining whether the compared responses between the operators and engineers could be legitimately called "significantly different."

Assumption 11

In determining the representativeness of mailed and returned engineers' responses by comparing the geographic distribution of responses, 146 engineers' returns were used that had postmarks indicating geographic origin. Twelve responses had no cancellations or obscured cancellation marks. Thus, a total of 158 engineers' responses were received. It is assumed that the results of the representativeness tests for the 146 respondents also apply to the other 12 respondents.

Definitions

The following definitions help clarify the terms used in this study. Because of the nature of definitions, outside references were given preference. Acronyms were put in alphabetical order for clarity and convenience.

35--see Standard Industrial Classification code.

37--see Standard Industrial Classification code.

3500 through 3599--see Standard Industrial Classification code.

3700 through 3799--see Standard Industrial Classification code.

AMT--see advanced manufacturing technology.

Advanced manufacturing technology (AMT)--a British term for computer integrated manufacturing. See computer integrated manufacturing.

Autonomy--is the core job characteristic that influences experiencing responsibility for work outcomes. As defined in Hackman and Oldham (1980), it is "The degree to which the job provides substantial freedom, independence, and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out" (p. 79).

Bench workers--the individuals in traditional unskilled, semiskilled, or skilled roles who perform manual tasks for an hourly wage. Also, the hourly wage has been a tradition, but many workers have become salaried.

Cells--a cell "consists of a CNC machine tool, a workpiece store, workpiece--and tool--change handling devices, and automatic control and supervision subsystems" (Warnecke & Steinhilper, 1985, p. 4). In this study, it also has referred to "stand alone" CNC equipment or to any metals working equipment whereby the equipment operator has used a computer as part of his or her job.

Cell operator--a person who has been at the cell site and has had monitoring and/or active roles and tasks which have been necessary for the reliable operation of the cell. The operator, for purposes of this study, also must have used a computer as part of his or her job.

CIM--see computer integrated manufacturing.

CNC--see computer numerical control.

Computer integrated manufacturing (CIM)--"an ongoing process that has sought to link all functions of a manufacturing enterprise into one organic whole through the use of computers, shared databases, and networking" (Staff, 1987, p. 6). Within this study the term was used interchangeably with AMT.

Computer numerical control (CNC)--having used numerical/electronic information to control processing. In the past, operators turned wheels and moved levers to position process tooling. With CNC, the wheels and levers have been moved electrically or pneumatically. Movement has stopped when a certain electronic value or pneumatic condition associated with the physical parameter desired has been reached. The determination of parameters has been made directly by the operator's having used a keyboard, magnetic tape, or a magnetic disk. Indirectly, parameters have been entered by indicating the product desired and then the computer has initiated action upon its having "looked up" the parameters.

Core job characteristics--those elements of a job that "are reasonably objective, measurable, changeable properties of the work itself that foster" (Hackman & Oldham, 1980, p. 77) the critical psychological states needed that are part of a motivated worker. These characteristics are skill variety, task identity, task significance, autonomy, and feedback from the job. Skill variety, task identity, and task significance influence the critical psychological state of "experienced meaningfulness of the work" (Hackman & Oldham, 1980, p. 77). Autonomy influences the state "experienced responsibility for outcomes of the work" (Hackman & Oldham, 1980, p. 77). Feedback from the job influences the state "knowledge of the actual results of the work activities" (Hackman & Oldham, 1980, p. 77).

Critical psychological states--the states of mind that determine whether a person is motivated to work. Hackman and Oldham (1980) see the states as "experienced meaningfulness of the work," experienced responsibility for outcomes of the work," and "knowledge of the actual results of the work activities" (p. 77). When a worker is "experiencing the meaningfulness," experiencing the responsibility," and getting "knowledge of results," the worker is in a mental state that facilitates work motivation.

Desires--what a person wants. The "wants" are not necessarily needed and this may be recognized by the person. In being distinct from expectations, the person does not feel that satisfying the wants is an obligation of others to the person.

Discrete manufacturing--is the production of goods that are countable such as cars or watches as opposed to continuous manufacturing where the goods are not countable such as flour or oils.

Elements of job enrichment--see job enrichment.

Expectations--what a person has wanted where the wants were not necessarily what was needed, as viewed by the person, but what the person felt was owed the self as a result of having assumed the roles and tasks of a job.

Extrinsic motivation--provided by "external rewards that have meaning or value after the work has been performed or away from the workplace. They provide little, if any, satisfaction when the work is being performed" (Ivancevich & Glueck, 1983, p. 388).

Feedback from the job--is the core job characteristic that influences knowledge of actual work results. According to Hackman and Oldham (1980), it is "The degree to which carrying out the work activities required by the job provides the individual with direct and clear information about the effectiveness of his or her performance" (p. 80).

FGM--see fifth generation management.

FMS--see flexible manufacturing system.

Fifth generation management (FGM)--whereas all previous managements utilized hierarchical communication schemes or serial communications, FGM has used parallel or "bulletin board" communication by which information entered to a computer system automatically has received the attention of those whom the information has affected.

First-line supervisors--foremen or a "secondhands."

Flexible manufacturing system (FMS)--"contains several automated machine tools of the universal or special type, and/or flexible manufacturing cells and, if necessary, further manual or automated workstations" (Warnecke & Steinhilper, 1985, p. 4).

Human factors--"the application of knowledge about human behavior, performance, capabilities, and limitations to the design and evaluation of the work environment" (Yanko & Askren, 1989, p. 3).

Industrialists--those who work in industry. Usually refers to those personnel who have decision making responsibilities that affect productivity, such as engineers and managers.

Integrated (and other forms and tenses of the word)--when used to modify manufacturing or has referred to manufacturing: "All the processing functions and related managerial functions are expressed in the form of data" (Clark, 1989, p. 10) and have been united by a common (usually computerized) communication scheme that has utilized the data.

Intrinsic motivation--"occurs when a person does something because they want to" (Hobson, et al., 1988, p. 6).

JDS--see Job Diagnostic Survey.

JIT--see just-in-time.

Job Diagnostic Survey (JDS)--survey and diagnostic instrument for determining whether a particular job needs change in whole or in part respecting the use of job enrichment. It provides direction in redesigning a job. Specifically it provides job content and job context measures of how workers view their jobs.

Job enrichment--according to Ivancevich and Glueck (1983), all job enrichment approaches "attempt to help the job incumbent satisfy personal needs while performing the job" (p. 121). According to Hackman and Oldham's approach (1980) to job enrichment, job enrichment involves adding elements to a job that help the worker experience positively job meaningfulness, responsibility for work outcomes, and knowledge of performance results. These three critical psychological states of the worker are considered necessary in achieving high internal work motivation. The elements of job enrichment measured, the inputs to the critical psychological states, are also termed core job characteristics. They are skill variety, task identity, task significance, autonomy, and feedback from the job. For the purposes of this study, an additional element would be one of the things that moderates the critical psychological states, would like growth need strength (WLGNS). The WLGNS is important because it indicates how much a person needs the core job characteristics in the person's being motivated to work.

Job Rating Form (JRF)--survey and diagnostic instrument for determining whether a particular job as viewed by the job designers is congruent with the job holder's view of the job when respectively comparing results of the JRF with results of the JDS.

JRF--see Job Rating Form.

Just-in-time (JIT)--has been basically a low-inventory approach to flexible manufacturing according to Lenz (1989). The product arrives at the customer's site just in time to be utilized. The customer could be another employee within the same installation.

Manufacturing engineers--has been similar to, and often has been a subset of, industrial engineering except manufacturing engineers usually have not worked outside of manufacturing while industrial engineers are often found working outside of manufacturing. The manufacturing engineer has appeared to be the answer to the need for the engineering generalist in industry.

Motivating potential score (MPS)--"A single index that reflects the overall potential of a job to foster internal work motivation on the part of job incumbents" (Hackman & Oldham, 1980, p. 81). The index incorporates the core job characteristic scores:

MPS = ((Skill Variety + Task Identity + Task Significance)/3) X Autonomy X Feedback from the Job. (1)

Motivation--the internal human mechanism that, in having responded to internal and/or external stimuli, has initiated physical action with mental intent to pursue either consciously or unconsciously, the attainment of a goal.

MPS--see motivating potential score.

Operators--see cell operator.

Production workers--see bench workers.

Productivity--an ambiguous term used throughout the manufacturing and business literature with little agreement as to its definition. It appears that it usually means the quantity and/or quality of goods in dollars per some unit. The unit is often per worker or per dollar of investment or dollar of raw materials, while the dollars in the numerator can be a measure of dollars of sales, dollars of goods produced, or dollars of capital gains. In general, the connotation of the word productivity is that more produced per worker or dollar invested is better. Productivity still appears to be synonymous with the traditional view of progress: More is better.

SIC--see Standard Industrial Classification code.

Skill variety--is the core job characteristic that influences experiencing work meaningfulness. According to Hackman and Oldham (1980), it is "The degree to which a job requires a variety of different activities in carrying out the work, involving the use of a number of different skills and talents of the person" (p. 78).

Standard industrial classification code (SIC)--a two to four digit numerical code that allows for classifying manufacturers by the products they produce. Established by the United States Department of Commerce, the codes facilitate the analysis of manufacturing data. For this study the codes 35 and 37 are used and include respectively 3500 through 3599 and 3700 through 3799. The 35 code means "machinery, except electrical" (Bureau of the Census, 1987, p. 1) and the code 37 means "transportation equipment" (Bureau of the Census, 1987, p. 1).

Supervisors--without contextual modifiers, foremen. With modifiers, members of management.

Task identity--is the core job characteristic that influences experiencing work meaningfulness. According to Hackman and Oldham (1980), it is "The degree to which a job requires completion of a 'whole' and identifiable piece of work, that is, doing a job from beginning to end with a visible outcome" (p. 78).

Task significance--is the core job characteristic that influences experiencing work meaningfulness. According to Hackman and Oldham (1980), it is "The degree to which the job has a substantial impact on the lives of other people, whether those people are in the immediate organization or in the world at large" (p. 79).

Technological capital--whereas capital for some people means the productive machinery (tangibles) purchased, technological capital means anything (tangibles and intangibles) which provides a technological advantage. It could be better machinery, the new technological information (knowledge) attending the machinery, the information distribution/utilization system of the machinery, and/or the experiences and/or skills of the workers who use the machinery. For example, patent possession and the employment of specialized welders would be forms of technological capital. Whereas capitalism recognizes the possession of products (what), technological capital adds the possession of processes (how and why).

WLGNS--see would like growth need strength.

Work cells--see cells.

Work group--usually has involved "contemporary manual assembly" (Bolwijn, Boorsma, van Breukelen, Brinkman, & Kumpe, 1986, p. 199) jobs where people often have been responsible for the assembly of a large and/or complex product that has required the skills and cooperation of 15-20 people.

Working environment--"'represents all that a worker observes and feels at his or her workplace'" (Wickham Skinner in Welter, 1986, p. 19).

Work situation--see working environment.

Would like growth need strength (WLGNS)--has been used by Hackman and Oldham (1980) in their measuring job desires that could have been satisfied by the job role and/or job tasks themselves. The WLGNS indicates how much core job characteristics are desired in the job design. Thus, a higher WLGNS would "amplify" the need for core job characteristics more than a lower WLGNS. It has been a numerical measure derived from averaging the scores for the considered job on six measures which have been treated in Research Questions 2, 3, 6, 8, 10, and 11 after 3 is subtracted from the response to each item.

Study Time Line and Costs

In acquiring the data for this study, time and fiscal costs were incurred. The time line in completing this study is shown in Appendix A. The monetary costs of collecting the information are shown in Appendix B. Mailing costs were based on 873 pieces mailed while other costs were based on 1000 pieces printed, 1000 stamped envelopes purchased, and 1000 names purchased. The differences are reflected in the fact that lead times for printing and obtaining envelopes were needed. When the mailing lists arrived (1000 total names), it was found that names had to be deleted.

CHAPTER 2

LITERATURE REVIEW

This literature review had three purposes. One purpose was to examine what motivates people and how such motivation relates specifically to cell operators. A second purpose was to provide engineers with information on job design psychology that was written by a technologist for technologists. The information base would allow the incorporation of elements of job enrichment into cell operator job designs. The third purpose was to demonstrate the author's competence in the fundamentals of job enrichment and motivation, that went beyond classroom learning, in adding credibility to the overall conduct of the study.

A Psychology of Work Primer

Because of the need to use terms throughout this review that are usually specific to psychology or specific to work psychology, it is necessary to briefly orient the reader to the basic psychological theories that are predominate in the review. Readers will then be familiar with the terms as they are used in the review. The "Hierarchy of Needs Theory" of Abraham Maslow and the "Motivation-Hygiene Theory" of Frederick Herzberg are examined. It is notable that the theories are useful in their general explanations of what motivates people. There are exceptions to all tenets of both theories. Neither Maslow nor Herzberg are dogmatic in any of their positions despite what other interpreters of their explanations state.

The Hierarchy of Needs Theory

Maslow (1962) envisioned each person as being on a spectrum of choice between two extremes of safety and growth. In being motivated to make safe choices, a person was tending toward satisfying basic or lower order needs. In growing as an individual, a person was pursuing satisfaction of higher order or growth needs. Maslow envisioned five levels of needs where the attainment of satisfaction at previous levels was generally required before other needs at higher levels could be satisfied. This was a very simplistic view which did not preclude any combination of exceptions. For example, the "starving artist" stereotype who would rather create than eat was possible. In general though, most people go from eating to creating and the levels of needs envisioned by Maslow (1970) were (a) physiological needs, (b) safety needs, (c) belongingness and love needs, (d) esteem needs, and (e) self-actualization needs.

Physiological needs are the organic needs of the organism such as the need for food, water, sleep, and oxygen. Of course, these needs are the most important as their satisfaction is necessary for the immediate or direct survival of the organism. These needs are lower order needs.

Safety needs are needs such as being secure, being free from fear, having order, and being protected. Satisfying these needs is attempting to reduce threats to the existence of the organism. Though satisfying these needs helps assure survival of the person as an organism, usually the threats to survival are not seen as immediate or direct threats. Safety needs are also lower order needs, but above physiological needs on the hierarchy of needs.

Attempting to satisfy belongingness and love needs results once the existence of the individual feels less threatened. The individualism gives way to awareness as a member of groups. The survival of the individual gives way to survival of the species, the ethnic group, the religious group, the culture, or any other perceived social entity. The desire for love and affection predominate in dealing with perceived "significant others" such as a spouse. In viewing the needs as necessary for survival of the species, the needs can be viewed as lower order needs. This author terms this phenomenon as "generic immortality." Viewed from other social perspectives, these needs could be considered higher order needs. In effect, these needs are transitional needs as a person goes from lower to higher order needs.

The drive to satisfy esteem needs results from the need for external confirmation of the individual's self-worth. That is, the individual needs to be valued or appreciated by others. The desire for self-respect and self-esteem are major needs. This author terms the extreme attempts to satisfy these needs as the need for "specific immortality" in the attempt to become known and thus live in the memory of others beyond death. The esteem needs are higher order needs which are attainable generally once the belongingness and love needs are satiated.

The drive to self-actualize, to be oneself, or to find oneself is the highest order of need. It is the result of the need for internal confirmation of the individual's self-worth. As Maslow terms it "What a man can be, he must be" (1970, p. 46). Respecting cell operators, the need to self-actualize should make the operator provide his or her best effort. Hopefully, this study can provide some insights into what job elements must, should, or could be in place to allow the operator to self-actualize at work within the roles and tasks of the job which result in high productivity.

The Motivation-Hygiene Theory

Until the publication of the Motivation-Hygiene Theory (Herzberg, Mausner, & Snyderman, 1959) in The Motivation to Work, there was a general belief that dissatisfaction and satisfaction were the extreme opposite ends of a single continuum upon which each person operated. Herzberg believed, respecting work activities, that there were two parallel continuums operating concurrently. On one continuum dissatisfaction was at one end while not being dissatisfied was on the other end. This continuum corresponded roughly with Maslow's lower order needs. Herzberg called the needs on the continuum hygiene or maintenance needs. The other continuum had satisfaction on one end with not being satisfied on the other end. This continuum corresponded similarly to Maslow's higher order needs. Herzberg called the needs on this continuum work motivators or motivational factors. Herzberg's theory appears to explain why some people are satisfied with work, but are still not productive while others appear dissatisfied, but are productive. That is, dissatisfaction and satisfaction appear to coexist concurrently within the same person. What is important is the degrees of dissatisfaction and satisfaction within the individual and how the individual values elements of the total work environment. In this study, attempts are made to look at one "individual," the cell operator, to determine what the "values" of the elements are of the operator's work environment.

Some of Herzberg's (1966) maintenance or hygiene needs are, company policy and administration, supervision, relations with the supervisor, relations with peers, relations with subordinates, pay, job security, personal life, working conditions, and status respecting the job or job importance. Some of the motivating factors are achievement, recognition, advancement, the nature of the work itself, personal growth on the job, and job responsibility. Hackman and Oldham (1980) incorporated the theory, along with other theories, into their job characteristics model. It is that model which is used to explain the meaning of the results of this study. The model is detailed later in this review and can be understood by referring to the definitions in the "Introduction." Relevant definitions are found for the terms autonomy, core job characteristics, critical psychological states, feedback from the job, job enrichment, skill variety, task identity, task significance, and would like growth need strength (WLGNS).

Historical Perspectives of Work Design and Work Attitudes

Jacques Ellul (1964) stated that the rapid development of machinery took place at a time when people were not ready for it. As a result, the "inhuman society" of Ellul in which people live today was created. Technique, the way things are accomplished, continued Ellul, was used to integrate the machine into society and with great subtlety man has been adapted by the use of technique to that which he did not normally adapt: "a world of steel" (p. 5).

The Technical View of Work

In the 1890s, Frederick Winslow Taylor applied the principles of machine design to the organization of work. This approach, known as Scientific Management (SM) or Taylorism, was the fitting of people to the job (Hackman & Oldham, 1980). Taylor, though having seen the worker in the most negative terms as lazy and malingering (Shaiken, 1984), was able to bring the unskilled laborer up to the level of machine operator (Drucker, 1967) which provided significant economic benefits to the worker and the owners of the factories. As a result, SM was to have a long modern tenure.

Taylor saw SM as a means for removing uncertainty of how a task was performed. The use of SM was not directed specifically toward work simplification despite what some of Taylor's followers espoused (Cooper, 1974). As control was the means to eliminating uncertainty, Taylor necessarily made simplistic assumptions about the psychological motives of the working man and by having done everything to eliminate those factors from job design, he was able to effect considerable control over the job content (Guest, 1967). "The worker became hardly more than a passive agent of the machine process" (p. 61). Continuing with Guest, the group did not matter to the Taylorists. Thus, the unions were formed because the Taylorists did not consider the social aspects of the work environment. The unions could and did meet the social requirements formed around the common concern of the worker of having been treated as a part of the machine (Barbash, 1967).

While Taylor emphasized a purely technical approach to machine design, Henry Ford introduced the assembly line, the use of which took Taylorism a step further by expanding work simplification, by adding machine pacing, and by requiring minimal mental attention (Guest, 1967). In 1915, Hoxie, in a report, summarized quite succinctly (from today's perspective) the feelings of labor at the time on SM. The Taylorists "did not recognize the humanitarian and social problems they were creating, nor that these problems were undermining any potential economic benefits. The practitioners seemed ignorant of the findings of contemporary economists and social scientists" (Howarth, 1984, pp. 28-29). From the background of the early practice of work design with its connotations of dehumanized work, modern industrial psychology began to emerge.

A Social/Psychological View of Work

Elton Mayo's experiments in the early 1920s have been considered by many to be the beginning of modern industrial sociology/psychology as he was specifically examining the sociological bases of work (Guest, 1967). Though his fixation was on sociological (work group activities) aspects of work, the results had greater implications for the individual worker. It was believed that the worker was a substantial element in the productivity equation. Until the 1950s, there persisted two opposing views of work that operated concurrently: Taylor's view with its productivity through technology premise and the sociological/psychological view expounded in a variety of developing perspectives of work motivation coexisted from the 1920s through the 1950s. The nontechnical "soft" approaches to work design were based on the premise that the individual was the real source of productivity. Details of the evolution of perspectives of worker attitudes from sociological/psychological beginnings, until the advent of sociotechnical theories of work, are treated later in this review in the section on relevant surveys and studies.

A Sociotechnical View of Work

Out of the work of Trist in the British coal mines (which, ironically, concerned the introduction of machine-intensive technologies) came the sociotechnical theory of Trist and Bamforth which was reported in 1951 (Heller, 1988). Specifically, "the only practical calculation is one which assesses the potential of the machine together with the human and social component that interacts with the machine" (p. 115). Davis, Cantor, and Hoffman (1955) thought it was doubtful that minimizing total production costs was attainable without integrating the motivational and technical requirements of a job. Davis et al. were perplexed and concerned by management's attempts to build up satisfaction outside of work (company sponsored sporting events is an example) and management's spending large sums of money to repair, through its human relations programs, the egos damaged by work. The investigators concluded from their study that "management designs jobs without systematic methods, without tested criteria, and without evaluating the effects of job designs on long-term productivity or costs" (p. 22). This was the continuing echo of the Hoxie report made forty years earlier. The reason for management's position was surmised by Davis et al. as management did not put any faith in motivational approaches. Thus, management preferred costly technical approaches.

By 1967, it was clear that a perspective of motivation and technology was in place when the design of work was considered. Though Drucker (1967) indicated that this dual concern had been in place for 60 years, it was at least obvious by the advent of the 1970s, that "what will be required in the future will be a combination of the advantages of Scientific Management with the contributions of behavioral science to the understanding of the nature of human work" (Guest, 1967, p. 64). By that time, man was starting to achieve harmony with his <u>work situation</u> wherein his needs as a complete human being were being addressed (Barbash, 1967).

An Enhanced Sociotechnical View of Work

Today, an additional perspective to job design, that has been examined best in terms of an approach used at Eaton Corporation, has been introduced. This perspective has been an evolution of the insights expressed in the famous "Eaton letter" (Scobel, 1986) which was a response to the company's need for insight into their "people problems." The thesis of the letter was that the managers of a company, through their policies, assumed the worst in man which suppressed the best in man. Assuming the opinions expressed by the employees in the letter were accurate, the Kearney, Nebraska Eaton management has utilized a laissez-faire approach to job design that would bring out the best in man. The promise of the approach, allowing people to find and stretch their limits, and its historical evolution was stated best by Maslow (1970) in his summarizing of Aristotle: "The essential difference is that we can now see not only what man is, but what he may become. That is to say that we can see not only surface, not only the actualities, but the potentialities as well" (p. 271).

Compared to "traditional" plants of comparable size, the output at the Kearney plant has been 35% higher (Scobel, 1986). The culture that nurtured worker commitment and loyalty that are needed by any company (Susman & Chase, 1986) evolved from an emphasis on the value of human resources (Scobel, 1986). Scobel, an Eaton employee, stated that there were actually times when productivity dips had been expected and have been considered desirable as such dips have been artifacts of the improvement process. Scobel continued: "Perhaps behavioral science's gallop is leaping over some very simple and moving truths" (p. 272) as "something constructive and productive is truly happening somehow." (p. 272). He concluded that at Eaton they have been convinced that trusting and respecting their employees produces an effective, cohesive workplace.

A View of Work Summary

Work design and work attitudes have evolved from technical implementations that have eliminated malingering to "hands-off" designs that have relied upon the inherent potentialities of people. Work has been truly transformed as Shaiken (1984) put it, over the past 100 years.

Automation

Automation has been a deceptive term that has had no certain denotative meaning, but it has had many connotative meanings, both positive and negative, depending on the communicators involved. In this literature review, automation primarily denotes a system designed to produce without human involvement except when corrective and/or opportunistic action has been required. This has meant that machines handle expected situations far better than man and that man has been best when handling unexpected situations. In the latter case, machines can not be utilized without continuous human intervention.

People and Automation: The Majchrzak View

When automated systems were first utilized, it was hoped that one of the biggest advantages would be the elimination of people and thereby error would be reduced in productive systems. It was found that while error at one level was eliminated, a whole new set of errors came with automation. That is, automated systems were still designed by people, and "automation does not eliminate the possibility of human error. It merely relocates the sources of human error to a different level" (Wickens, 1984, pp. 492-493). In fact, not only was the case for the elimination of people without a premise or promise, but even with more sophisticated forms of automation, such as flexible manufacturing systems (FMSs), people have been essential to system function as people have been needed to make adjustments, provide for unexpected integrations, and provide and demand immediate responses (Majchrzak, 1988). Specifically, continued Majchrzak, direct labor has been needed in FMS to modify instructions, check quality, troubleshoot, and watch input variations. Majchrzak has identified six equipment parameters that determine the level of human involvement. They are (a) integration, (b) rigidity, (c) work flow predictability, (d) feedback, (e) safety, and (f) the nature of the machine operators' jobs.

Respecting integration, Majchrzak (1988) cited one study in which she was involved wherein 22 users of CAM stand-alone equipment and 22 users of CIM in discrete manufacturing were surveyed. It was found that the level of integration was a major factor in assessing the impacts of technology on humans. Indeed, task choices were dramatically different between successful CAM and CIM users. Overall the reliabilities of the CAM stand-alone system and the CIM discrete system were disappointing.

According to Majchrzak (1988), rigidity resulted in increased dependence on key cells while rerouting for flexibility led to a bigger mix of job tasks and the assignment of priorities to the tasks. If work flow was unpredictable, which has been the normal case with just-in-time (JIT), then the workers faced more variety and challenge, and required more discretion in decision making. Work flow in cell designs is characteristically unpredictable. This implies that cell operators face variety, challenge, and job discretion in their jobs. It will be seen later in this review that variety, challenge, and job discretion reflect higher order needs. It may be inferred then, that operators with the desire to satisfy higher order needs may be required in the factory of the future. The fourth parameter considered in determining the level of human involvement is feedback. Majchrzak felt that there was currently no technical learning curve in place for accurate machine feedback and response. Thus, "the operator needs to have a role in the feedback loop" (p. 27). Again, it was seen that feedback was an important component of job design models that utilized the higher order needs of people.

Majchrzak (1988) thought that designers of sophisticated computer-dependent manufacturing systems needed to particularly notice that new equipment, which naturally has made operators anxious, also has new problems which result in increased anxiety levels "which reduces attention to detail and leads to accidents" (p. 28). This reduction in attention was seen as a serious problem because new integrated systems have an interdependency that makes attention to detail a priority.

Majchrzak stated (1988) that in determining the role of people in FMS and/or CIM, job designers must reflect upon four dimensions of the machine operators. The dimensions were, for this review, posed as questions: (a) How much coordination is required?, (b) Who needs what information where and when?, (c) What levels of reliability are needed such that redundant systems utilizing people in the roles of checkers are needed?, and (d) What is the level of, area of, and degree of discretion (autonomy) required?

Majchrzak (1988) warned that "ignoring human resource issues until after the technology has been selected or implemented creates the potential for human resource problems that are so severe that the capital investment for an expensive FMS or other flexible automation system may be completely negated" (p. 7). Also, the assumption that people can rapidly adjust to change has been totally unwarranted because of the inability to predict within the same order of magnitude the time and personnel required to train people for their roles and tasks with the new technologies.

In advancing an understanding of automation and its impact on humans in their work relationships, the book, <u>The Human Side of</u>

Factory Automation, (1988) by Ann Majchrzak, is highly recommended to the automation job designer as it was well-researched, highly informative, and the author concentrated on problems and issues relevant to the contemporary designer. The only notable qualifier in using the book was that the author is a psychologist and not a technologist. Though the presentation would have been considered a notable achievement for any technologist, the author has a habit of translating the technological scenarios to psychological analogies which have lost the essence of the original events. Majchrzak probably did this to facilitate her own understanding as a psychologist. This precluded the technologist's having any additional insights into the stated scenarios. Overall, the book was a brilliant piece of research and it will surely be a landmark book in relating that productivity comes from the workers in their use of automation.

People and Automation: Other Considerations

Gerwin (1982) found, in a company using FMS, that most blue collar workers, and especially operators, felt their jobs were stressful and provided little motivation. Particularly notable was the lack of an identifiable piece of work, the lack of autonomy, and a need for personal growth and development. Barbash (1976) indicated that "craft and automated technologies are associated with the least discontent and assembly-line systems with the most" (p. 14). Katz (1975) stated that automation has increased the motivational potentials of employees. That is, people found they could actually have more control rather than less in using automation. Herzberg, Mausner, and Snyderman (1967) believed this higher motivation was a result of workers feeling they have more control over their part in the production process. Thus, some of the desirable motivators, such as recognition for work well done and having more autonomy at work, have appeared achievable for the production worker in automation. Harris (1976) felt that the work life of the automation worker has improved. He stated that highly automated industries have been characterized by operators monitoring, repairing, adjusting, and maintaining the process equipment. Though this is typical of job enrichment, it also focuses responsibility for overall success or failure of the enterprise on individual units because of the matrix of cell interactions typical of integrated systems. Thus, the operator is in a stressful environment. Yet the operator has enjoyed an improved work life as the result of receiving increased attention and its complementary assistance. This increase in attention is expected because a highly integrated system requires the attention in satisfying the much greater need to avoid breakdowns.

Majchrzak (1988) characterized a highly integrated FMS as CIM. Cetron (1984) believed that, although "American factories are poised for an unprecedented surge in productivity via new, sophisticated automation" (p. 106), the American factory worker would have to accept lower wages and the manager must be more creative. For the factory worker, a major question has been posited: Can workers be more productive while working for lower wages?

That is, could the satisfying of intrinsic motivation be accomplished successfully in offsetting the deprivation of lower order needs in opposition to the tenets of prominent theories on work motivation? Perhaps, Cetron was inaccurate in his lower wage need prediction. Perhaps, job designers could "carry the day" with potent work designs that have been built upon high order needs. For managers perhaps, the real challenge in being more creative in utilizing "new sophisticated automation" has been directing job designs that have human components incorporated within the designs. Until action is taken in directing job design, there are too many "perhaps" akin to wishful thinking along the path to maintaining and increasing productivity.

Job Design

Lewis Mumford (Kranzberg & Purcell, 1967) believed human values have defined progress, where progress is "more is better." Mumford believed that in progressing, it was necessary to distinguish between the machine and its system. It was implied then, that in providing for progress through technology, care must be taken not to subject man to the machine. That is, man has been a part of many machine systems, but man has also been distinct from those same systems: Man has subjected himself to the machine to attain economic benefits that have provided freedom to experience activities that have satisfied higher order needs.

In meeting the challenge to provide work that incorporates higher order needs, it has been realized there are more complex people than there are complex jobs and there have been more simpler jobs than there have been simple people (Hackman & Oldham, 1980). For the job designer then, man and work as a system has been perceived as an enigma, a mixed blessing: Fill the relatively few complex jobs by choosing from the many complex people, which provides higher order need satisfaction for a few while it provides high productivity. Then fill the many simple jobs with the few simple people and the remaining many complex people. This would provide society with economic benefits at a low productivity level through the efforts of many bored and frustrated people. For those concerned with the complexity of designing CIM systems, it has appeared that there may be no problem once the right people have been found to fill the operator roles in the CIM cells, as the cell has appeared to be complex and has required the attention of complex people.

Job Design: Some Contemporary Views

Drucker (1967) stated that the premise of Gestalt psychology has been that the parts that make up a whole are not seen, as each is a part of the whole which gives the whole a distinction that allows for its recognition as a whole. Drucker wondered if this is what "man/machine designers" (p. 20) did: They made man part of the machine in applying the systems approach. Boddy and Buchanan (1986) paraphrased Charles Perrow, a sociologist, in his belief that considerable human accountability was required in good designs:

> engineering design which fails to take into account human and organizational factors can create costs for equipment users that include excessive fatigue, boredom, excessive workload, isolation, frustration, and perhaps accidents. These costs have clear and negative implications for performance. (pp. 28-29)

Vansina, Hoebeke, and Taillieu (1987) found that "normal" system accidents were artifacts of systems with a poor "fit" between people and technology and such accidents lead to disasters. Majchrzak (1988) went further. She felt that the nontechnical aspects attending to the subject technologies have been a greater challenge than the technologies themselves. Indeed, failing to plan for people or attempting to eliminate people has been a flawed rationale. In having retrofitted existing systems for CIM, piecemeal modifications have been a normal part of any sociotechnical design and improvement change, and these changes have interacted with organizational and manpower innovations (Hartmann, Nicholas, Sorge, & Warner, 1983). Thus, job design has been the joint product of human factors and technological factors (Cooper, 1974). Boddy and Buchanan (1986) felt that though people may get the "residual" tasks that machines cannot perform, it has been those residual tasks that have been extremely significant. Therefore, the design of residual tasks has been an important consideration that should not be discounted because of connotations of the term "residual."

Taylor (1979) found, in a case study of a chemical process, that statistical quality control for product uniformity was only attainable when "people approaches" utilizing pride in craftsmanship, involvement, and autonomy were incorporated. Thus, there were tangible results from intangible considerations that were not provided by any tangible means alone. In expanding this approach, Hackman and Oldham (1980) believed that many jobs have been restructured to improve the relationships between people and their jobs. Susman and Chase (1986) provided a reference for determining whether people should be upgraded or technology should be emphasized in improving performance. They stated that if there has been variance in a key element or substantial variance overall or a need to sever learning loops, people have been upgraded in providing system control. For those who have attempted to reveal the existence of these conditions, Majchrzak (1988) has provided four stages in identifying the human impacts of new technologies. These stages in analyzing new or potential purchases have been: (a) examine the equipment's distinct features; (b) determine how the features affect jobs; (c) determine what training needs must exist; and (d) determine the significance of the equipment in organizational survival, production processes, and human infrastructure. This pragmatic approach has allowed the designer to weigh overall benefits to the whole organization and it has prevented suboptimization and fixation on an organizational development "fad." Thus, optimization has resulted and "if the combination of technology and people is to operate at optimal effectiveness, both may have to make sacrifices . . . . [as] the human operator's job cannot often be translated into a workable technical system" (Heller, 1988, p. 115).

So, often there has been no clear best approach. Majchrzak (1988) stated that the different ways in which the same technologies can be implemented had been the determinant of the good, bad, or indifferent consequences of new technologies for machine operators. Thus, practical considerations eventually have determined the levels of human and technological attributes of a particular job design. Davis and Taylor (1979) believe there is a dilemma: "Systems analysts and engineers appear to be caught between what they believe to be employees' needs and potential, and what they, as designers, are obliged to deliver" (p. 61). Job decisions have been based on weighted equipment, human, and company survival factors (Majchrzak, 1988). Scobel (1986) felt that complex job designs often have not been necessary. At the Eaton Corporation plant in Kearney, Nebraska, the employees, who in large part had designed their own jobs, usually (75% of them) had wanted to know more about the production process as a whole. Many had done their own repair (one third) while a third had troubleshot their own machines. These people, as Hackman and Oldham (1980) expressed it, have been pushing work and fun closer together, where "fun" means they are enjoying their work. They have received a "kick" (p. 60) out of their work. So it can be seen that people are the answer to the problem of productivity rather than people being the problem in assuring productivity--or has this been an acceptable assumption? In examining this assumption, the following comment made in a book on work design published in 1985 is considered. It can be seen that there are still followers of the tenet of eliminating or minimizing the involvement of people in using CIM: "Process planning is a bridge between design and manufacturing. A process planning system that minimizes human decision making and data preparation is therefore desirable" (Chang & Wysk, 1985, p. 215). Perhaps, this study has provided some insight into answers to the question, What are the roles and tasks of people in CIM utilization? The opinions of manufacturing engineers on the elements of job enrichment of the cell operator's roles and tasks are very important.

Job Design and Work Motivation Theories

Hackman and Oldham's Work Redesign (1980), Chapter 3: "The Approaches to Change: The Job Itself," was effectively reviewed in part in this examination of work motivation theories. The specific examination of the chapter was conducted for two reasons: (a) Hackman and Oldham's review was succinct and (b) as the instruments used for surveying the groups cell operators and manufacturing engineers were revisions of the instruments detailed in Work Redesign, the authors' views in Chapter 3 were important in understanding the conducting of this study. However, Hackman and Oldham's examination of motivation-hygiene theory is omitted as this researcher's perspective of the theory has been presented earlier in this review.

Classical organization theory. According to classical organization theorists, operational efficiency was the ultimate measurement criteria for the success of a work design. Often this resulted in a division of labor which resulted in substantial productivity increases that were probably due to honing of specialized skills, the fixing of attention on a specific object, work simplification requiring the use and handling of a minimum number of tools, and worker movement was minimized as the workers usually occupied specific work stations. Industrial engineering evolved as the result of attempts to systematically investigate and quantify the tenets of classical organizational theory.

Activation theory. Activation theorists postulated that productive people have been stimulated people. To keep people stimulated then, it has been necessary to vary the type of stimulus (such as using lights of different colors), vary the magnitude of the stimulus (such as utilizing loud versus soft sounds), and vary the sensory modality of the stimulus (such as requiring the use of audible prompts versus visual prompts). According to this theory, varying the stimuli is ultimately important in preventing people from adjusting to or assimilating the stimuli into the environmental background. That is, an entity adjusted to or environmentally assimilated is no longer a stimulus.

Job characteristics theory. "The basic idea is to build into jobs those attributes that create conditions for high work motivation, satisfaction, and performance" (Hackman & Oldham, 1980, p. 59). Based on measuring feelings of workers about job characteristics such as task variety, task identity, autonomy, and job-based feedback, this theory states that a worker's attitudes and behavior are related to the characteristics. Positive provision for the characteristics in a job should result in increased work motivation and productivity.

Sociotechnical theory. The essence of sociotechnical theory has been that work resultants have been optimized when people and technology have interacted synergistically in job designs. For its consideration in Hackman and Oldham's (1980) approach to job design, it was added that there has been an awareness requiring accountability: All sociotechnical systems have been imbedded in a larger working environment with mutually complimentary or detrimental effects.

The job characteristics model. The model has been actually a graphical presentation of a job characteristics/motivation-hygiene/sociotechnical theory. Its supporters have proposed that core job characteristics of skill variety, task identity, task significance, autonomy, and feedback from a job have been the inputs to a person's critical psychological state with dimensions of "experienced meaningfulness of work," "experienced responsibilities for the outcomes of work," and "knowledge of the actual results of the work activities" (Hackman & Oldham, 1980, p. 90). Depending on the absence, presence, or amounts of the core job characteristics, there has existed a resultant critical psychological state exhibited by a certain level of anxiety which has been manifested as action in the attempted attainment of certain outcomes of "high internal work motivation," "high 'growth' satisfaction," "high general satisfaction," and "high work effectiveness" (p. 90). The characteristics, states, and outcomes also have been moderated by a person's knowledge and skill, growth need strength, and satisfaction with the work context. This researcher's interpretation of the model for purposes of this study is shown in Figure C-1 of Appendix C.

Hackman and Oldham's (1980) model served as an integration of the various work motivation theories. The use of the model showed that all of the theories each explain, in part, the motivation to work of people. Though some theories fit well while others were "forced" into the model, the use of the model did not omit any critical elements of the theories. Thus, whatever model people actually fit best and even though the job may not exist, it could probably be "well-sketched" by the job characteristics model. The use of the model served as the reference for this study as the instruments used were specifically designed for measuring various attributes of the model. Of particular import to this study was the measure, in part, of cell operator growth needs strength where growth needs strength is a moderator in the job characteristics model. The use of the model then provided, in part, the relationship between growth need strength of cell operators and their expected work outcomes.

Hackman and Oldham (1980) felt that:

> one of the major influences on organizational productivity is the quality of the relationship between people who do the work and the jobs they perform. If there is a good 'fit' between people and their jobs, such that productive work is a personally rewarding experience, then there may be little for management to do to foster high

> motivation and satisfaction--other than support the healthy person-job relationship that exists. (p. 4)

Relevant Surveys and Studies

Balchin (Herzberg, Mausner, Peterson, & Capwell, 1957) stated that man worked for three reasons: (a) to survive, (b) to fulfill obligations to society, and (c) because man wanted to work. He felt that for Western (culture) man, survival as a motivator was effectively an extinguished drive. The fulfillment of obligations was felt to be a relatively unsatisfying resultant. The primary drive to work then has been the desire to work. Mace (Herzberg et al., 1957) recognized that all three reasons for working have operated concurrently though factors that have affected the desire to work have been significant for modern Western man. Hygiene factors, those things that have served in the satisfying of basic needs and in the prevention of dissatisfaction, have not been enough for people (Herzberg et al., 1967).

The Factors that Motivate

The results of Elton Mayo's experiments in the 1920s at the Hawthorne Works of the Western Electric Company were perceived as a threat to management. He found that productivity increased during his illumination experiments not because of specifically changing lighting variables, but because the women, the workers, were involved with the experiments and they saw the experiments as interesting. The potential of the relationship, that worker involvement leads to productivity increases, was what threatened the managers who adhered to Scientific Management principles that excluded the workers from any part of the work design in the managers perceived need to control the processing.

The Job Attitude Research Program. Herzberg et al. (1957) found that monotony and boredom were probably the major causes in making jobs unpleasant. This observation was based on their reviewing the research of many researchers and they particularly referenced the studies of Munsterberg, Lipmann, Cain, Wyatt, Barmack, Smith, Walker, and Joiner.

Interpersonal relationships assume a greater importance when the accomplishments of the individual in the work effort are indiscernable (Herzberg et al., 1967). Bingham (Herzberg et al., 1957) in 1928, found four areas of worker interaction: (a) relation to work, (b) relations with others, (c) relations with the supervisor, and (d) relations of the work group with management. Reflection upon these observations of Herzberg et al. (1967) and Bingham has indicated that the needs of the worker have pulled the worker toward organized labor while the actions of the "scientific" managers have pushed the workers toward the unions. Unions have served an important social need.

Thorndike (Herzberg et al., 1957) found five opportunities for satisfaction. They were (a) mastering the work, (b) submission to authority, (c) sociability, (d) identifying with the company, and (e) the "satisfyingness" or good feeling a person gets from doing the work. Katz (Herzberg et al., 1957) examined the workers' morale dimensions which were identified as intrinsic needs, group pride, extrinsic needs, and identifying with the company.

As has been seen, much of the information available has been provided by Frederick Herzberg, Bernard Mausner, Richard O. Peterson, and Dora Capwell in their book, Job Attitudes: Review of Research and Opinion (1957) which was the result of sponsorship by the Board of Directors of Psychological Service of Pittsburgh of the Job Attitude Research Program. The authors examined 150 studies (The number cited in Herzberg et al., 1967, is 155: The correct number is not known.) from 1920 to 1954 in their attempts to identify the major factors in work that have affected the way people work. The ten major, general factors identified were (a) intrinsic aspects of the job, (b) supervision, (c) working conditions, (d) wages, (e) opportunities for advancement, (f) security, (g) company and management, (h) social aspects of the job, (i) communication, and (j) benefits (Herzberg et al., 1957, pp. 39-40). The most important specific job aspects, in descending order, were found to be job security, job interest, opportunities for advancement, appreciation by supervision, identifying with the company and management, general (excluding ease of the work) intrinsic job aspects, the quality of supervision, the working conditions, quality of communications, the hours worked, the ease of the work, and work benefits. These factors were the distillation of 16 studies which involved over 11000 employees. It has been apparent that many researchers have used results from the Job Attitude Research Program in the development of instruments that were used to measure job satisfaction, work motivation, or work desires and expectations. Herzberg et al. (1957) also noted that interest in job attitudes research was increasing almost exponentially as only one study of attitudes and job expectations was conducted from 1920 to 1924 and the research accelerated until 67 studies were conducted from 1950 to 1954.

Of great significance for future research were the findings that there have been six apparently independent factors that have influenced job attitudes. Those factors have been (a) general job satisfaction and morale, (b) attitudes toward the company and its policies, (c) the intrinsic aspects of the job, (d) attitudes toward immediate supervision, (e) the need to self-actualize, and (f) working conditions (Herzberg et al., 1957, pp. 71-72).

Other observations. England and Stein (1976) examined the attitudes of occupational work groups. Across all general groups examined, subjects "strongly agreed" that having friendly coworkers was important to them such that it received the highest percentage of strongly agree responses for all seven groups. In ranking the responses by percentages of respondents strongly agreeing with the need for each of the 11 factors, pay ranked no higher than fourth for any one (professionals) of the seven groups examined. Respecting craftspeoples' responses, as craftspeople would have comprised the group within which cell operators would probably have been classified today, pay had ranked sixth of 11 factors examined. The type of work performed had the second highest percentage of responses. In examining the results, it has been seen that there has been support for the conjectures of researchers in the area of predicting worker responses. Those conjectures are that those who predict worker responses probably have been projecting or self-referencing. That is, in their predictions of worker responses to the expectations and desires of the job, the people predicting have superimposed their value system on those for whom they have been predicting responses.

In the 1982 Agenda Foundation survey of job satisfaction (Yankelovich & Harman, 1988), it was found that 52% of those surveyed felt they had to do the best job no matter what the pay. It appears that there may have been a strong need for self-esteem in the work, although some workers could have meant that they had a strong sense of obligation which was found to be the case in earlier studies. It has been discomforting to notice that the subject of obligation in the context of work has been de-emphasized in surveying work attitudes. Not only has the question of researcher biases been a relevant one, but this researcher has been concerned about the general implications for bias in the selection of factors in the use of survey instruments.

Findings Resulting from the Use of Motivating Work Factors

The identification of factors that have motivated people at work has evolved from their being a goal in much research to their having been used as a means to further research on human motivation. The evolution has continued with the factors having had implications for behavior at work and toward the designing of work that has utilized the implications for behavior.

Comparing white and blue collar workers. Quinn, Staines, and McCullough (Hackman & Oldham, 1980) examined what was considered the most important aspects of work for blue and white collar workers. Relatively speaking, blue collar workers expressed lower order or basic needs preferences while white collar workers were oriented to higher order or intrinsic needs. That is, blue collar workers had pay and job security in their top five needs while white collar workers had no basic needs rating a top five position. Both groups had "I have enough information to get the job done," "the work is interesting," and "I receive enough help and equipment to get the job done" in their top five needs.

Work goals and the hierarchy of needs. Gert Hofstede (1972) used the data from an international electronics manufacturer's survey of 60000 of its Western (as in Western civilization) workers in 50 countries over a four year (1968 into 1972) period. Workers were asked to rate, by importance, 19 factors of the ideal job. They used a written questionnaire. Hofstede ranked these factors according to average scores of importance. With little doubt, 16 of the factors evolved out of factors identified by Herzberg and his associates in 1957. Of the workers surveyed, 2500 were plant technicians, the group within which cell operators would fit. They rated job security as the most important to them in the ideal job. In decreasing order the next four desires were (a) higher earnings,

(b) job challenge, (c) working well with the boss, and (d) having an opportunity for advancement. The professional technical group was the group within which manufacturing engineers would have had the best fit. Unfortunately, that group did not work within any plant as did manufacturing engineers, but there was no other group that offered a better fit. For the professional technical people, the order of the top five choices in decreasing order were (a) having opportunities for training, (b) being able to keep up-to-date, (c) having job autonomy, (d) being able to use their skills, and (e) having cooperative coworkers. Though this group offered the best fit for engineers in getting a perspective of the engineers' needs, it has appeared that the fit has not been acceptable as the group surveyed worked out of branch service offices and it has been seen that their responses have reflected the needs of customer service personnel.

Using Maslow's (1970) hierarchy of needs, Hofstede (1972) placed the first four important needs of the groups surveyed. The plant technicians group was easily the best fit to the hierarchy of the groups ranked. The first two ranked needs, "security" and "earnings" were indeed lower order needs. However, the third ranked need, "job challenge" is a higher order need while "good relations with the boss," which was ranked fourth, was a social need. These results and the overall results provided by Hofstede have lent partial support for Maslow's hierarchy of needs. Hofstede found that "there are greater differences between job categories than there are between countries when it comes to employee motivation" (p. 72). This study has provided substantial support for the importance of the job in people's overall lives. There has been then, good support for identifying the growth needs and their importance for the occupation, cell operators.

The 1987 INC survey. The INC magazine survey (Hartman & Pearlstein, 1987) used the results of 500 people from companies that employed more than 10, but less than 500 employees concerning the satisfactions the employees derived from their jobs. A mailed questionnaire was used. The results were compared to the results of a 1987 Hay Group employee attitude survey of 1900 companies employing 500 to 50000 employees that showed sales growth each year for the five previous years. Thus, big company versus growing company results were presented by the INC publishers. Though INC personnel found that the people employed at growing companies were more satisfied with work than employees at big companies, the people's biggest gripes at growing companies: poor pay and benefits, favoritism, good work is not rewarded, and the work was not satisfying, indicated the companies were ready for organizing by labor unions. Of the six factors used in measuring work satisfaction, four have been familiar: (a) challenging and interesting work, (b) having input to the way work is accomplished, (c) a sense of accomplishment, and (d) employees are treated with respect. The other two factors, (a) having a quality product and (b) the company being viewed as competitive, could have been perceived as being aspects of the familiar factor "identifying with the company." As the readership of INC has been managers of growing companies and growing companies have required possessing good "images," the "identifying with the company" argument has been plausible. As having a quality product and the company was viewed as competitive had the two highest favorable percentages (90% and 86% respectively) by far (65% was next for "the workers were treated with respect"), then identification with the company has appeared to have been the most important component of satisfaction for the employee of a growing company. The conclusion was that the secret to company success was motivated and enthusiastic employees.

The 1989 Gallup Organization survey. This survey of 669 people, conducted by telephone from July 18 through July 21, 1989, found that "those who like their jobs the most feel they have opportunities for promotion, the chance to use their own initiative and to learn new skills and concepts" (Kohut & DeStefano, 1989, p. 24). Those who personally identified with work were the most satisfied. Of those surveyed, 89% were satisfied in part with their jobs, but only 39% said they would stay in the same job! Factory workers tended "to be the least satisfied with all aspects of their job" (p. 22). The researchers believed that job satisfaction was related to a person's age and personal commitment to the job while sex, race, and income were not closely related to job satisfaction.

Methodology Rationale

In this section, literature and specific references from the literature were cited in providing overall support for the reasoning behind the specific conduct of this study. In looking at this study, there has been an attempt to be thorough on the broadest level possible. Thus anything, that could have provided support for the conducting of this study, was noted and has been considered.

Behind the Study Structure

England and Stein (1976) expressed a need for occupational norms as there were large occupational differences concerning job attitudes. Hofstede (1972) stated that in general, a job may not be "just a job" that is: "Employees are people in jobs--and it makes a tremendous difference what jobs they are in" (p. 72). However, "management has assumed it knows what the employees want, and this assumption does not hold" (Herzberg et al., 1957, p. 59). If it was shown that sustaining the engineer-shop floor team contributed toward improving shop floor effectiveness, then at least engineers would no longer be viewed as a foreign element on the outside of the group that has needed to know (Ettlie, 1988).

Some reflections. In the implementation of new technologies, it has been a serious mistake not to see that value judgments have been imbedded in the technologies. The ramification has been that the system designer, who has not considered job challenge, could provide a system drastically different from the one the operator has anticipated (Majchrzak, 1988). As Majchrzak stated, people have differed in the amount of job challenge desired. Thus, it has been important that the average cell operator's rating of job challenge should be determined.

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In a 1976 study, wherein job criteria were examined, Taylor (reporting in 1979) found that American engineers saw job design from a slightly extrinsic perspective. They felt that job design was more their business than the business of any other occupation including the people in the job roles being designed! In having considered job design aspects, it has been shown that there tended to be agreement between the manufacturing engineers' and systems designers' rankings of criteria utilized in breaking work flow into tasks that provided the greatest product quantity at the lowest cost. It has been presumed then, that engineers were treating job design as a discipline in the use of systematic approaches to problem-solving toward the accomplishment of known goals and objectives. A very interesting and relevant observation by Hedberg and Mumford (1979) was that computer systems designers

> operate with two models of man--one operational, one theoretical. One which they produce when actually designing systems for users, the other which they produce when asked to consider the subject of human needs such as job satisfaction at an intellectual level. (p. 53)

For this study, it has been extremely important when surveying manufacturing engineers to make clear that they were to respond in Section 3 (of the survey instruments used for this study) as the cell operators would have responded and not as the engineers felt about the job. In summary, Hedberg and Mumford suggested: "Perhaps the strongest influence that will change the practical model of man held by the systems designer will be when the users get up and shout 'we are not as you think we are'" (p. 53). Perhaps, this study could make the "shout" of one group, the cell operators, a little louder.

Majchrzak (1988) believed that not sharing and expressing value judgments could lead to hostility. When workers were asked directly about pay, pay was rated highly, but when the question was asked indirectly, the importance of pay dropped dramatically (Herzberg et al., 1957). In continuing with Herzberg et al., supervisors consistently ranked wages higher, and intrinsic needs and the value of communication lower than their subordinates ranked the factors. These points provided further support for determining the actual value system of the cell operators. Shaiken's (1984) belief that the foreman lacked the contact with the specific jobs that a leader has had, helped delineate the acceptance or rejection of some job titles from the cell operator survey. That is, "leader" in the job title was acceptable while "foreman" in the job title excluded the person from sampling.

<u>The critical need for conducting this study now</u>. Ettlie (1988) found in a study of 19 plants implementing advanced manufacturing technology (AMT), where the implementation team members were already selected, that there were many changes in job attributes during a year of implementation for skilled tradespeople, operators, engineers, and supervisors. There were general declines in job

autonomy, skill variety, job satisfaction, and role stress. However, the rates of decline and the resulting levels of decline were such that any projection or self-referencing tendencies present could have magnified or propagated misunderstandings during the process. This was notable as one would expect after a year of working together that people would have "known" each other. Apparently then, the dynamics of CIM implementation have been quite unpredictable. It is possible that the implementation process by its nature could have drawn people apart.

There has been strong support for the utility of conducting the cell operator study using respondents who have been involved with CIM or have had a high chance of becoming involved with CIM because it is those respondents who could probably benefit the most from study results. Also, there has been strong support for conducting this study as it could be said, in general, that many and probably most respondents have been engaged in or have been considering engaging in the process of CIM implementation concurrent with the activity of this study. Because CIM has been considered new and consequently there has been no time for the systems implemented to fully mature, it has been likely that misunderstandings have been very prominent. These misunderstandings occurred just when such misunderstandings could have caused the most harm: during the period when this study was conducted. Thus, if there have been tendencies to not know what motivates cell operators, they should have been revealed during the conducting of the study when such a tendency could have seriously compromised CIM efforts. Without this study and studies like it, there has been the possibility that causes of CIM failures would not be found. This would result because causes having origins in self-referencing or self-projections, would have been greatly moderated or extinguished by the time those efforts were examined for causes of the problems. That is, results could have been confounded by the general declines expressed earlier. With responsive implementation of the results of this study and others like it, successful CIM efforts become more likely. In the event that CIM efforts continue to fail, this study and studies like it provide records of the dynamics of CIM development. Thus, the efforts that characterized early CIM "behavior" can be analyzed to determine the sources of dysfunctional CIM efforts long after the earlier behavior has been extinguished in the progression to more "mature" systems. That is, CIM "rehabilitation" becomes possible. During a general nationwide program of CIM implementation, time has been available to capture and record the human dynamics of the process. Otherwise, CIM disappointments could continue without some perspectives on what was happening during the first attempts to implement CIM on a significant scale. "First attempts" means anything being done during the conducting of this study. It has not been comforting to note that Herzberg et al. (1957) in reviewing studies utilizing the methodology of predicting the job attitudes of others, commented that there was a relative inability "to predict the importance of various job factors in the employees' attitudes" (p. 59). The implications have been even graver in reflecting on the importance and cost of CIM implementation and the expected differences between manufacturing engineers and cell operators. It has not helped to know that Herzberg et al. were speaking of a time when manufacturing was relatively static and those unable to predict were the supervisors of those for whom they made the predictions.

Developing the Study Structure

This specific type of study has not been conducted previously. That is, a study of the prediction of cell operator needs by manufacturing engineers, as the cell operators see the needs, has not been done. Previously, the case for the need to conduct such a study was made. Herein, the related studies treating the predicting of worker attitudes and needs by supervisors are examined.

The Labor Relations Institute study. The Labor Relations Institute (LRI) study of foremen and hourly employees and the ability of the foremen to predict the desires and expectations of their subordinates was reported in 1946 (Harris, 1976). Despite frequent referencing of this study in the literature (Albrecht, 1978; Harris, 1976; Kovach, 1980; 1987), this researcher found very little concerning the study. All that has been known, beyond the information available from publications referencing the study, is that the LRI is now defunct. An extensive interlibrary search has provided only the suggestion that the study probably was originally reported in a monograph which made searching difficult and beyond the use of normal search-conducting techniques. Thus, the following information has evolved from "reports of the report."

There was general agreement on the report of the results: Harris (1976) and Albrecht (1978) presented the same results while Kovach (1980) had apparently inverted the ninth and tenth supervisors' ranked factors in his report of his 1980 study. They were respectively "sympathetic understanding of personal problems" and "feeling 'in' on things." The rankings (which are listed in part in conjunction with a comparison of other studies in Tables D-1 and D-2 of Appendix D), "varied widely in the importance given to each factor" (Harris, 1976, p. 214). Though the other reports (Albrecht, 1978; Kovach, 1980) concurred, there was no statistical treatment of the rankings in checking for significance. This was probably because there was no universally-accepted statistically-simple way of treating the results. However, some logical treatment has been better than the "feeling" that others get when "looking at" the results.

With the supervisors treated as a single entity of "the supervisor" and the employees treated as "the employee" plus the varying sample sizes treated as attributes of "the supervisor" and "the employee," then a rank correlation test (Spearman's ρ, nonparametric) revealed there was no statistical difference from zero at the .05 confidence level. Thus, the results were different, but there was no basis for saying such results varied widely. What was notable was that the supervisors saw their subordinates as being motivated by lower order needs as the supervisors' four top ranked factors were, in decreasing ranked order, (a) "good wages," (b) "job security," (c) "promotion and growth opportunities," and (d) "good working conditions." The employees top four preferences were, in decreasing ranked order, (a) "full appreciation of work done," (b) "feeling 'in' on things," (c) "sympathetic understanding of personal problems," and (d) "job security." Thus, the employees ranked first two higher order needs which were followed by a social need before they made their first lower order choice. Respecting job design requirements, it has been expected that job designers who have held perceptions similar to the supervisors' perceptions would have seen the locus of control for motivating work as having been external to the employees within the roles of the jobs designed. Motivation probably has been perceived as a function of the personnel department! There has been, of course, the need to provide hygienic (in the language of Herzberg, 1967) working conditions. With the workers having perceived their needs as intrinsic with respect to the job itself, there was the potential for seeing work as undesirable because, despite the prospects of good wages and job security, the job designs would not have addressed the workers' expectations.

Kovach's 1980 study. Kenneth Kovach administered the 1946 questionnaire to 200 employees and their immediate supervisors in 1980. He found little difference from the 1946 study. The only statistical analysis was that the sum of the differences decreased from 42 to 34 in 1980. This researcher found, using the same analyses developed for the LRI, that there was still no significant difference at the .05 significance level. Though job security was still ranked fourth by the employees, as it was ranked in 1946, and it was still the only basic need ranked in the top four "wants from work," the first three wants were all higher order needs in 1980. They were, ranked in descending order, (a) "interesting work," (b) "full appreciation of work done," and (c) "feeling of being in on things." The supervisors' first four wants predicted for their employees were the same as the 1946 study. Though there was a slight increase in the rank correlation coefficient since 1946, there was an actual increase in the gap between the views of work held by the employees and their supervisors regarding employees' wants. That is, the employees shifted toward higher order wants while the supervisors predictions did not change. In reflecting on the needs of the average cell operator (whose job has appeared to require considerable autonomy) there could be serious problems in job design if the average manufacturing engineer sees the operator as primarily motivated by basic needs satisfaction. That is, a cell operator job designed by considering only basic needs satisfaction may not only be devoid of actual motivating potential, but it may be designed to minimize rather than maximize operator involvement. Kovach attributed the differences in the study to the supervisors' self-referencing, that is, the supervisor referred to his or her value system in determining expectations of the employees' value system. A partial consideration of the rankings found in this study is included in Appendix D, in Tables D-1 and D-2.

Kovach's 1986 study. In 1986, Kovach expanded his study to include 1000 employees and 100 supervisors within the same organizations. Respecting the four top choices of the employees and the predictions of those choices by the supervisors, there were no changes from the 1980 study.

Some interesting aspects of the 1986 study appeared in the breakdown of the rankings into occupational choices. Relevant to this study were the rankings of the groups "blue-collar skilled" and "lower nonsupervisory" which respectively were comparable to the groups cell operators and manufacturing engineers. It was notable then, that the "blue-collar skilled" had the first four rankings listed in decreasing order of desire as (a) "interesting work," (b) "feeling of being in on things," (c) "job security," and (d) "good wages." The "lower nonsupervisory" employees ranked, in decreasing order of desire, the first four wants as (a) "good wages," (b) "job security," (c) "interesting work," and (d) "full appreciation of work done." If self-referencing was a significant problem in predicting-type studies, then the manufacturing engineers' responses to this CIM study should have been similar to the rankings of the "lower nonsupervisory" employees for their predictions of the cell operator's wants.

Also interesting were the rankings of the "blue-collared skilled" which revealed that the first two rankings were higher order needs and the third and fourth ranked wants were basic needs. There was then a difference between the first four rankings of the two groups which appeared almost as a reversal of one to the other that indicated that if self-referencing was a problem, which Kovach maintained for supervisors, it should have shown a difference in this CIM study, but it was difficult to say in which direction the differences would have been manifested the most. Therefore, the research questions of this study were answered using two-tailed tests. The biggest differences between the groups were in the rankings of "feeling in on things" and "good wages." If self-referencing was a problem, it was predicted that (assuming significant differences were found between the groups of cell operators and manufacturing engineers) significance should be found between the wants "good wages" and "feeling in on things." The partial results of this study are shown in Appendix D, Tables D-1 and D-2.

In compiling the information for Tables D-1, D-2, and D-3, similar factors, as indicated by item wording, between or among the studies were compared. Much judgment was used in examining the items comparable between studies. Thus, the results should be viewed as only "rough" comparisons. The factor wordings are based on the JDS wording of items. Where items had no comparable equivalents in other studies, the items were left out. For example, an item shown as a fourth-ranked item in one study could be shown as second-ranked in comparing it to items in other studies. This could result if two items ranked second and third in the study were omitted entirely from consideration in making comparisons among other studies. The omission would be justified by the lack of comparable items in the other studies. Comparisons in Tables D-1, D-2, and/or D-3 would show the fourth ranked item as ranked second for the considered study in comparing it to items in other studies.

The Hoh study. Although Hoh did not indicate when his study took place, he reported the results in 1980. He surveyed 50 sawmill employees and their six supervisors. The blue-collar workers were asked to provide ratings in each of three categories for each job satisfaction factor using a Likert scale of one to seven. The categories were the amount each factor was present in the job, the amount each factor should be in the job, and the importance of each factor to the person. As a result, Hoh was able to get a ranking of factors, by importance, and by a satisfaction value for each factor. This approach was unique and could have been more valuable except Hoh compromised his own instrument. There were 16 factors which were permutations of factors used in the LRI study and they came specifically from Yankelovich's 1973 study of American youth. However, Hoh's claim of using the top 16 factors of the 35 factors rated in the Yankelovich study was incorrect. He apparently confused the presentation of results in a figure (On page 26 of Yankelovich, 1973: This researcher agrees that the figure was confusing.) as Hoh had seven of the lowest-rated factors on his instrument. Hoh then ranked the factors by weighted ratings and compared them to the supervisors' rankings (supervisors actually ranked the factors) of how the employees would have valued the factors. Thus, Hoh compared literal rankings with their inherent assumed equal intervals to derived rankings which reflected variable intervals. Of course, the results "looked interesting," but because of apparent methodological inconsistencies their meaningfulness was limited. Hoh also asked supervisors to rank the factors important to themselves. Such information was invaluable in treating the self-referencing hypotheses of Kovach and others as the supervisors' value systems were measured directly and at the same point in time as the supervisors' predictions of their subordinates' desires. It was found that the supervisor's personal value system was primarily oriented to higher order needs while the supervisors saw their subordinates as primarily oriented to the basic lower order needs. Hoh's study then, lent support for self-referencing theories in predicting the needs of others and it provided some external validity for the supervisor-higher order needs/subordinate-lower order needs dichotomy that was revealed in the LRI study. As it was not known whether Kovach's 1980 study or Hoh's study came first, it can only be said that one of them provided some external validity for the other. The Hoh instrument was different enough in its form from the LRI instrument (used by Kovach) to justify the term "external" validity. Overall Hoh's methodology was suspect so as to make only the generalizations mentioned reliable. A partial presentation of the results of the rankings were included in Appendix D, Tables D-1 and D-3.

The Purdue studies. In 1954, the results of three dissertation studies were reported. The origin of all three studies was Purdue University and the studies appeared to have been conducted under the direction of H. H. Remmers, who was interested in the value of predictions of supervisors of various types of responses made by subordinates. The revelation of relationships of predictions to productivity appeared to have been the goal of the studies.

Nagle (1954) studied 217 to 441 employees and their 14 to 21 supervisors at one company. Supervisors were asked to predict employee responses to a "tailor-made" written questionnaire. He also developed a productivity ranking of the 14 departments involved by having six of the company's executives rank the departments by using a deck of 14 cards and the paired-comparison technique. He found a high correlation between employees' attitudes and the productivity of their department. Importantly, the more "positive" the average attitudes of employees of a department, the more highly ranked was the productivity of the department. The more favorably-regarded supervisors were better able to predict employee attitudes. Their subordinates also had favorable attitudes toward the company and plant management. The more favorably-regarded was the supervisor, the higher was the productivity of the supervisor's department. The intercorrelations were high (-.42 to -.82 and +.63 to +.88) for the six variables measured. Nagle provided strong support for a positive relationship between the ability to predict employee needs and productivity.

Thus, there appeared to be some basis for an argument that manufacturing engineers' abilities to predict or not to predict cell operator ratings would have important implications for productivity.

Patton (1954) attempted to determine if secondhands (foremen) understood their subordinates and supervisors by measuring their ability to empathize with those two groups. Empathy was inferred from the secondhands' ability to predict employee responses on the test How Supervise? which has been a general test used in dealing with the opinions of supervisors concerning their problems and practices. Patton found that secondhands could not predict the responses of managers or their subordinates and the secondhands were projecting negatively (they underestimated scale responses) to managers and positively (they overestimated scale responses) to their subordinates. An interesting note was that the results of a 1989 Fortune review of recent work attitude surveys were similar (Farnham, 1989).

Johnson (1954) investigated and found no relationship between subordinate morale and the supervisor's ability to predict responses to the test How Supervise? However, the ability of subordinates with high morale in predicting the responses of their supervisors was significantly different from subordinates with low morale in predicting supervisors' responses. Johnson did not clarify why it was important to know if subordinates could or could not predict the responses of their supervisors. In finding significant differences, there were no clear implications for such results.

Choosing the instrument. The studies that involved prediction as part of the methodology utilized various instruments. The How Supervise? was not designed to measure general work attitudes. Its use in the Johnson and Patton studies was explained by the researchers' environment while pursuing their doctorates: H. H. Remmers was their advisor and H. H. Remmers was a codeveloper of the How Supervise? instrument.

Kovach used the LRI instrument for his studies and it appeared to be a good instrument. As there were no known studies of the instrument's reliability, various validities, or correlations, "appearance" or face validity was the only criterion that was used. Hoh's instrument was incorrectly constructed as it used an incorrect view of Yankelovich's (1973) results. Yankelovich's instrument was primarily a survey instrument that had its item evolution in the results of the Herzberg et al. review (1957).

Revisions of the Job Diagnostic Survey (JDS) and the Job Rating Form (JRF) were the data collection instruments used in this research. The use of these revised instruments provided many advantages. One advantage was that the original instruments had been used often without serious problems (problems that make results generally suspect) manifesting themselves. Because the instrument has been used often, another advantage was that there was a large occupational data base with which results could be compared. This lead to another advantage which was that surveying production workers was not needed as their would like growth need strength (WLGNS) mean and standard deviation were determined from previous use of the JDS (under the job title, "bench workers"). As the JRF is a variation of the JDS and was designed for some predicting or comparison of responses to JDS responses, another advantage was that the JDS and JRF were suited for use in determining and predicting job attitudes. An important advantage was that there were studies available regarding the reliability, validity, congruence, dimensionality, and correlation of the JDS. The fact that the JDS had undergone rigorous pilot studies as the Yale Job Inventory was also reassuring. No challenges to results, derived from use of the JDS and JRF, were expected as would be the case in the use of instruments developed for use just in this study.

The Job Diagnostic Survey

In explaining their approach to the design and redesign of work, Hackman and Oldham (1980) emphasized the major features of the approach as having been:

1. Focusing on specific jobs.

2. Treating separately the design of work for individuals and groups.

3. Allowing for individual and systematic properties.

4. Requiring diagnostic data.

5. Linking behavioral theory and implementation technologies.

These features were reflected in the design and intended usage of the JDS and the JRF. Specifically, the JDS was designed, at least in part, as a test-retest instrument such that pre-intervention data were required and the measurement of job change was needed (Hackman & Oldham, 1975).

In General

Dunham (1976) thought the JDS so poor he was afraid that he would be understood as saying the instrument was worthless. He "softened" his comments with "the results of this study are not enough to argue for total abandonment of a multidimensional construct of job characteristics" (p. 409) and "whatever the ultimate outcome, the present state of the art is one in which the dimensionality and theory of job characteristics has not been well established" (p. 409). It appeared that in one breath Dunham dismembered the JDS and then provided, indirectly, an acceptable reason for the poor performance he found in using the instrument that would still support the continued use of the instrument.

Dunham's specific recommendations treated the instrument's dimensionality: He thought there was need for a single-factor job complexity measure and that there was need for a four-factor solution wherein task variety and autonomy were combined. In a similar critique, Fried and Ferris (1986) felt that their factor analysis supported the legitimacy of job feedback and task identity as job characteristic dimensions, while there was doubt concerning task significance, skill variety, and autonomy. They noticed that the three dimensions loaded on a single factor, autonomy. Aldag, Barr, and Brief (1981) considered the dimensionality as unacceptable as there appeared to be only three dimensions: job feedback, task identity, and autonomy. Lee and Klein (1982) also noted that two autonomy items loaded highest on feedback, task significance, skill variety, and task identity factors which indicated the items were confounded by the factors such that the autonomy measures may really have been artifacts of the factors. Thus, the items were not independent measures of autonomy. However, they felt that their research supported the "a priori dimensionality" or face validity of the JDS. As that meant the instrumental variables appeared to be acceptable, one implication of this study was the inferring of a good respondent return rate. Hackman and Oldham (1975) stated, in evaluating their own instrument, "the job dimensions are positively related to measures of work satisfaction and motivation, and are generally independent of the two measures of growth need strength" (p. 166; emphases added).

Green, Armenakis, Marbert, and Bedeian (1979) expressed concern over the method variance. They stated that, in Section 2, that meaningfulness of the content scales appeared weak and the item formatting was a confounding factor in interpreting results in an applied setting. It was conjectured that for some respondents (they tested textile operatives), the respondents provided similar responses to Section 1 because they did not read the relatively difficult-to-read items. They concluded "the production-type worker is likely to be comparatively low" (p. 187) in attentiveness and reading comprehension such that "the JDS in its present form may not be appropriate for use with manufacturing operatives" (p. 187).

As cell operators have been considered "manufacturing operatives," the reference of Green et al. implied the need to check the responses for reading difficulty. For this study, Section 6 could have constituted the entire instrument. However, including Section 1 also has served as a check for reading comprehension problems in looking for the "similarity of responses" artifact. Reflection indicated that the cell operator had certain job skills and knowledge that required the reading of technical documentation that should have precluded concerns over reading comprehension.

Idaszak and Dragow (1987) claimed to have found a measurement artifact as the result of item scoring reversal (Scoring reversal has been the use of the word "not" or its equivalent in the elicitation of a "not y" response instead of a "y" response). They recommended the use of their items which had modified wording which eliminated the artifact. They felt it was ironic that the artifact was created as it was known that Hackman and Oldham deliberately incorporated the reversal to control and/or monitor instrument reliability problems. The problems resulted from providing similar responses due to the failure to read or due to the inability to read all of the items. What Idaszak and Dragow overlooked was that their "cure" may have been worse than the "disease," as test constructors often have included items designed to trace reliability problems. There was then, a tradeoff between validity and reliability which emphasized validity first, but which still required, pragmatically speaking, quality (reliability) of responses. The authors noted that the artifact grew weaker as respondents' education and reading skills increased.

Validity

Aldag, Barr, and Brief (1981) found for construct validity, that the convergent validity was acceptable and the substantive validity was questionable, but acceptable. Hackman and Oldham (1975) found, overall, that convergence was moderate (+.31 to +.64). However, convergence was very low for feedback (+.07) respecting the groups of supervisors and employees. Respecting employees and observers, it was +.13 and it was negative (-.14) for supervisors and observers. Having considered the implications of feedback respecting the interactions of employees and supervisors, it was likely that feedback responses, under the conditions of knowing that both supervisors and employees were being tested, were probably very subjective. Also, Aldag et al. found the discriminate validity unacceptable.

Reliability

Aldag et al. (1981) determined internal consistency reliability to have been acceptable while Ferris and Gilmore (1985) indicated, for nearly 900 jobs in 56 organizations, that the average internal consistency was +.70. Such consistency, it was hoped, would allow for the discrimination of answers between manufacturing engineers' and cell operators' in detecting real differences and hopefully provide enough "margin for error" such that any differences that did exist could not be discounted as due to reliability problems. At the time, there appeared to be no information on test-retest reliability despite the fact that one of the intended uses of the JDS has been test-retest!

Correlation

Respecting the utility of the JDS, Umstot, Bell, and Mitchell (Aldag et al., 1981) found that the r correlation coefficient between the motivating potential score (MPS) and overall job satisfaction was positive and significant ($r = +.71$, $p < .001$). However, the low negative correlation between MPS and productivity ($r = -.11$), seemed to provide some support for the contention that the satisfied worker has not necessarily been productive.

Summary

In this literature review, it has been shown that motivating factors such as those found in Hackman and Oldham's WLGNS have been the basis for studies involving the needs and the perceived needs of subordinates respecting the subordinates' and the supervisors' responses to the subordinates' needs. Often the needs were termed expectations or desires. As it was consistently found that supervisors could not predict subordinate needs, there was strong support for this study. The review also revealed the importance of job enrichment factors such as skill variety, task identity, task significance, autonomy, and feedback. In general, they were seen as very important, in optimizing productivity. Thus, there was substantial support for comparing the responses of operators and engineers to items on elements of job enrichment.

The WLGNS items of Section 3 of the JDS serve as the "templates" for the research questions. Thus, variations of Hackman and Oldham's instruments, the Job Diagnostic Survey (JDS) and the Job Rating Form (JRF), were used for the data collection instruments because the purpose of the instruments is to provide information on the elements of job enrichment and the WLGNS. The methodology that follows is used to assure reliable processes for collecting and using the information that is derived from the use of the variations of the JDS and the JRF.

Chapter 3
METHODOLOGY

The following research design, procedures, and statistical analyses were utilized in obtaining the data and in determining the significance of the data. Study control concerns were addressed as they arose which explained the necessity for additional extensions of the methodology.

The core job characteristics were graphed and motivating potential scores (MPSs) were calculated. This was done for responses to Sections 1 and 2 of the instrument variations of the Job Diagnostic Survey (JDS) and the Job Rating Form (JRF). The response differences should have given some direction to the engineers in their attempt to utilize the would like growth need strength (WLGNS) of the cell operator.

Design

In Figures 1, 2, and 3, the study designs which served to facilitate data collection activities, to compare data collected, and to direct the discussion of results are displayed. There were two groups of subjects, cell operators and manufacturing engineers. The cell operators responded to the JDS instrument variation while the manufacturing engineers responded to the JRF instrument variation. Each instrument provided diagnostic data for evaluating existing and desired cell operator job design, and information was provided for comparing both group perspectives regarding the growth needs and the would like growth need strength (WLGNS) of the average cell

operators ——→ JDS → cell operator WLGNS
↓
t test → differences?
↑
manufacturing engineers → JRF → cell operator WLGNS

Figure 1. Test design for Research Questions 1 through 11.

cell operators ——→ JDS → cell operator WLGNS
↓
t test → differences?
↑
manufacturing engineers → JRF → cell operator WLGNS

Figure 2. Test design for Research Question 12.

cell operator WLGNS
↓
quite discrepant test → differences?
↑
bench worker WLGNS

Figure 3. Test design for Research Question 13.

operator. Testing for differences of perspectives of job growth needs of the cell operator was one of the primary purposes of this study. In order to satisfy the secondary purpose of this study (getting engineers to see the importance of cell operator growth needs in job design) a core job characteristics profile was made. The profile is a combination of line segments that join average responses (y variables) to the core job characteristics (x variables) of skill variety, task identity, task significance, autonomy, and feedback from the job. The characteristics are also known as elements of job enrichment. Graphing of cell operator ratings versus engineer ratings provided differences of perspectives of the existing cell operator job. Sections 1 and 2 provided the information that resulted in the profiles. In conjunction with responses to Section 3, the determinations of existing or potential problems with the cell operator job design were treated in the discussion of results.

Subjects

There were two groups of subjects: the average cell operators and the average manufacturing engineers. An "average" subject of each group is one that fits the results of the surveys. That is, if only one person responded with the results of one of the surveys, then that person would be the average subject. Upon self-administration of a variation of the JDS by cell operators and self-administration of a variation of the JRF by manufacturing engineers, two values for each of 32 instrument items or variables resulted. Results of Sections 1 and 2 were used to provide cell operator core job characteristics profiles (line graphing combinations of 15 items) and in diagnosing potential problems in cell operator job design. There were 21 diagnostic variables (Sections 1 and 2) and 11 potential growth need variables (Section 3, Research Questions 1 through 11). In responding to the research questions, 26 pairs of scores resulted (One score, bench operators' WLGNS was archival in origin). Testing each of the growth needs answered Research Questions 1 through 11. The WLGNS, a numerical value derived from the six actual growth needs of the 11 potential growth needs, was used for comparing scores, in one test, between cell operators and engineers (Research Question 12). The WLGNS, as determined by the cell operators also was used in one test to compare the WLGNS of cell operators to the WLGNS of bench workers, the latter also having been known as production workers (Research Question 13). Bench worker mean and standard deviation statistics were available from an archival source (Hackman & Oldham, 1980, p. 317). Figures 4, 5, and 6 show the listing of the items as examined in each Section of the instrument variations of the JDS and JRF.

Measurement

Seven-point Likert scales were used exclusively on the variations of the JDS and JRF. For Section 1 responses, each variable of seven variables had its own specific scale and unit. Section 2 used one scale for referencing the responses for all 14 variables. The scale unit was accuracy. While Sections 1 and 2 scales both had a range of

working closely with people (Item #1)
job autonomy (Item #2)
a "whole" piece of work (Item #3)
job variety (Item #4)
job significance (Item #5)
context feedback (Item #6)
job content feedback (Item #7)

Figure 4. Section 1 items or variables.

using high-level skills (Item #1)
cooperating with others (Item #2)
a "whole" piece of work (Items #3, 11)
job content feedback (Items #4, 12)
job variety (Item #5)
working with people (Item #6)
context feedback (Items #7, 10)
job significance (Items #8, 14)
job autonomy (Items #9, 13)

Figure 5. Section 2 items or variables.

respect and fair treatment (from the supervisor: Item #1)
stimulating and challenging work (Item #2)
job autonomy (Items #3, 8)
job security (Item #4)
friendly coworkers (Item #5)
self-actualization (Items #6, 10)
pay and benefits (Item #7)
achievement (Items #9, 11)

Figure 6. Section 3 items or variables.

one through seven, Section 3 items (11 variables) used a common scale for referencing with a range of 4 through 10 and the unit was effectively How much do you want this? The scale did allow for some degree of intrainterval marking. Technically the respondent could have and may have envisioned an infinite set of choices. Thus, the data tabulator could have occasionally judged what value was selected. In the discussion of results, it is seen that a judgment concern was unwarranted.

The Instruments

The JDS and the JRF required modifications to make them best-suited for use as mail survey instruments and in the JDS/JRF comparison of responses from both instruments. The literature review also provided compelling reasons for using the JDS and the JRF.

The JDS. The JDS was reduced from seven sections to three as Sections 3, 4, 5, and 7 did not provide information relevant to this study. Section 6 of the original instrument became Section 3 of the revised JDS. The first part of the instrument was new and provided up to six possible responses that could be used in combination in determining whether the respondent was a cell operator. The fifth item of the first part requested the job title which also provided demographic information. The sixth item inquired of years and months of experience which was included for use of the results beyond the dissertation. There was some rewording of the instrument in correcting typographical errors, in preventing confusion because the instrument was being used out of context, and because original sections were absent. Graphical changes were also made to facilitate readability, appearance, response accuracy, and results tabulation accuracy. J. Richard Hackman's (personal communication, postmarked July 23, 1990) suggestion that this instrument be termed "a revised JDS" (RJDS) was used (See Appendix E, Figure E-1).

The JRF. The JRF was increased from two to three sections as it was required that the respondents predict cell operator WLGNS. This required adding the JDS Section 6, with modifications, to the JRF as Section 3. The modifications were changing the wording of 6 of 11 items by replacing the word "my" with the words "his or her." This transformed, with complimentary instructional changes, the responses from those of respondents' addressing their own needs to respondents' addressing the needs of others. With such minor changes, piloting beyond advisory input was unnecessary. In keeping with referencing the revision of the JDS, the revised JRF was known as "a revised JRF" (RJRF).

The instrument was introduced with a part requiring the respondents to answer concretely whether the person was or was not an engineer. Checking no required excluding the person's responses from consideration. The respondent was also asked to include his or her job title and years of experience in the job. Such information allowed for the exclusion or inclusion of responses if the respondent failed to state concretely that he or she was a manufacturing engineer. It also allowed for the exclusion of supervisors who were not identified on the original mailing list. Those supervisors who had been manufacturing engineers were also excluded as it was believed that just changing jobs could "distort" opinions.

Cell Operator Profiles and Job Diagnostics

Sections 1 and 2 of the RJDS and the RJRF were used to provide information for graphing core job characteristics using the methodology of Hackman and Oldham (1980). Scores were graphed from combinations of means for responses from both sections on each instrument which resulted in two superimposed graphs, one representing RJDS responses and one representing RJRF responses. Then the motivating potential score (MPS) was calculated. There were seven job characteristics: skill variety, task identity, task significance, autonomy, feedback from the job itself, feedback from agents, and dealing with others. The first five characteristics were termed "core job characteristics." Figure 7 shows how scores were

Skill variety score:

Section 1: Item 4 mean

Section 2: Items 1 and 5 means (Item 5 is reverse scored:

Score = (8 - (mean response))

Task identity score:

Section 1: Item 3 mean

Section 2: Items 3 (reverse scored) and 11 means

Task significance score:

Section 1: Item 5 mean

Section 2: Items 8 and 14 (Item 14 is reverse scored) means

Autonomy score:

Section 1: Item 2 mean

Section 2: Items 9 (reverse scored) and 13 means

Feedback from the job itself score:

Section 1: Item 7 mean

Section 2: Items 4 and 12 (Item 12 is reverse scored) means

Figure 7. Determining the core job characteristics scores.

determined for graphing reasons. The item means were averaged in finding a particular score. Then the score was graphed. This was prescribed by Hackman and Oldham (1980, pp. 303-304). If the superimposed RJDS and RJRF graphs did not result in the crossing of lines in connecting respective points of each graph by an unbroken single line (for each graph) from left to right, then it was assumed that there were no substantial problems in job design. The crossing of lines indicated attention should be directed toward the characteristic of the job that was plotted above or below the line causing the intersection. Thus, profiles that appeared "similarly-shaped" indicated the likelihood that problems did not exist in job designs respecting core job characteristics. This graphical analysis approach was provided by Hackman and Oldham (1980).

MPS = ((Skill Variety + Task Identity + Task Significance)/3) X Autonomy X Feedback from the Job. (1)

Procedures

The general guideline in detailing the procedures was to provide enough information to allow study replication and to establish the veracity of the results. Where doubts were manifested directly or their manifestations were implied that could jeopardize the significance of results, the concerns were examined in detail. The jeopardizing the significance of results meant any concern that could lead to expressed differences in results as being due to differences in methodology rather than actual response differences. This definition established the criteria for identifying and allaying concerns: A concern was identified when it was possible that differences in results were construed as arising from the methodological permutations. This concern was allayed by negating it the extent that the methodological concerns still remaining could not have been responsible for the significant result differences.

The Cell Operator

The titles used for any jobs that could infer cell operators as being part of the population of jobs described were also very broad as to which jobs were actually encompassed by the titles. Thus, the operational definition of the cell operator was any person who checked the first statement of the statements in Figure 8 and who also checked any one of the other statements or any combination of the statements following the first statements.

The sample was obtained by purchasing a mailing list from Gardner Publications, Incorporated, Cincinnati, Ohio. The list comprised subscribers to Modern Machine Shop and Production magazines. There were only 332 names found that appeared to fit the job title requirements of machinist or machine operator. It was decided that the entire population of machinists and machine operators would be surveyed. Respecting the generalizing of results, the mailing list represented a sample of convenience from the set of all possible cell operators, machinists, and machine operators. A

_____	Yes, I operate or run metals machining equipment.
_____	Yes, I use a computer (PLCs, microcomputers, or etc.) on my job.
_____	I use a computer in helping with the processing of machined parts.
_____	I use a computer in determining which parts will be machined next.

Figure 8. The statements used in identifying the cell operators.

major concern was determining if the sample represented the population because a random sample could not be used in assuring representativeness. How this was accomplished is indicated in the methodology.

It was found that the County Business Patterns (Bureau of the Census, 1989; 1988; 1987) published by the United States Bureau of the Census each year for each county and parish in the United States had specific data on all aspects of manufacturing in the United States. The Standard Industrial Classification (SIC) codes were sufficiently precise such that it was easy to identify the establishments engaged in machining and that were likely to be involved with CIM. Specifically those establishments having 1000 or more employees and identified as engaged in "machinery, except electrical" (SIC 35) or "transportation equipment" (SIC 37) were the most likely users of CIM in some form.

Though it was assumed that the machinists' mailing list was representative of the population of cell operators, an r correlation coefficient was calculated by comparing the differences between frequency counts by state of CIM users and the mailing list addressees. This determined if there was a relationship between CIM users and the mailing list addressees that would allow inferring that the mailing list members could be involved with or could have the potential to be involved with CIM. The calculations were performed using the list with 48 names removed as some job titles indicated the people were supervisors. All supervisors were excluded as it was difficult to determine a supervisor's background.

The sample size of the mailing for potential cell operators was 284 (332 - 48 = 284). The mailing list was known to include individuals who were not cell operators. However, their location and quantity were unknown. The statements of Figure 8 would allow for the identification of the cell operators who were a subset of machinists and machine operators. It was decided to determine another r correlation and a test for its significance using the returns of those who responded, the original data on manufacturing establishment counts, and the location, by state, of the counts. It was hoped returns would still show that the sample represented the population of all cell operators.

A χ^2 "goodness-of-fit" test was also performed using respondents and the mailing list. Frequency counts, grouped by geographic region (groups of states), of respondents were compared to frequency counts, by grouped states, of mailing list addressees. Significant differences ($p < .05$) would have indicated that the respondents could not be considered as representative of the mailing list group.

Manufacturing Engineers

The mailing list for the manufacturing engineers was also drawn from subscribers of Modern Machine Shop and Production magazines. As the title manufacturing engineer had far broader applicability than the titles used for the cell operator group, restrictions were placed on the selection of the sample subjects. Economic concerns also severely restricted the size of the list that could be purchased. The restrictions that generated 1710 names were the job title manufacturing engineer, SIC of 35 or 37 and an establishment size of 1000 or more employees.

The purchase of only 1000 total names was affordable as there was already a commitment to purchasing 332 names of machinists. A list of 668 of 1710 names available was requested. As mailing list randomization is normally accomplished by nth random sampling, the list that resulted was not a random sample. It was necessary then, to use the same process of determining the r correlation coefficient and testing for significance that was used to investigate representativeness of the cell operator sample. The calculations were made using a list with 79 names removed. The names were removed when job titles indicated the addressees were supervisors. As a result, 589 (668 - 79 = 589) engineers were surveyed.

A χ^2 "goodness-of-fit" test, like that performed in testing for representativeness of the cell operator sample, was also performed on the manufacturing engineers' returns in determining whether the sample represented the group surveyed. Significant difference at the .05 level would have indicated the respondents did not represent the group surveyed.

Increasing Response Rates

Having carefully worked toward assuring the utility of the instruments and the representativeness of the samples, it was necessary to assure an acceptable return rate. Obtaining at least 30 usable returned instruments for each group, operators and engineers, was the goal of the return rate maximization methodology as 30 is the number traditionally accepted as sufficient for assuming a normally distributed sample for statistical testing.

Timing. It was originally desired that surveying begin in May, 1990. The survey was sent out on June 15, 1990 with the premise that people reflected more about their jobs prior to vacationing and upon returning from vacations than at other times of the year. Thus, it was hoped the June mailing would increase the return rate because the respondents would be reflecting upon their jobs and responding to a survey would provide an outlet for those reflections.

Upon making inquiry of the Greenville Office of the United States Postal Service, it was indicated that the instruments would be in the California respondents' hands no later than June 25, 1990. However, it was known that some respondents would receive them by June 18, 1990. If too much time (two weeks for California respondents: to July 9, 1990) was given for responding to the surveys, it was believed those receiving surveys early would not respond early. That is, they would believe they had plenty of time to respond. As a result, they might not respond at all. It was decided to risk good return rates from those receiving an instrument early against poor return rates from those receiving a late instrument. This was accomplished by indicating that any returns postmarked after June 29, 1990 "may" not receive consideration.

The instrument. Another reason for not using the additional sections of the JDS was that it constituted an instrument much too long for being a mailed questionnaire. Although the JDS and the JRF could have been used as mailed questionnaire instruments, the instruments were designed for face-to-face responding. The desired questionnaire was then thought to be one that had at least 20 items (to facilitate internal reliability). The JRF had a total of 21 items for measuring the core job characteristics. With the 11 items of the JDS of the original Section 6 needed to measure the WLGNS, the use of 32 items resulted. Each instrument was printed (duplexed) on a single sheet of 11' X 17" 60# paper that was folded to produce four 8 1/2" X 11" pages. The instruments were printed on colored (goldenrod) stock. The wording was physically proportional in anticipation of potential reading problems of some cell operators and in anticipation of operators having to read under poor lighting conditions. The RJDS is shown in Appendix F, in Figures F-1, F-2, F-3, and F-4. The RJRF is shown in Appendix F, in Figures F-5, F-6, F-7, and F-8.

The cover letter. The cover letter was limited to one page. It included a request for responding, the purpose of the study, and the importance of responding. Respondents were advised to keep a record of their responses if they desired results, so they could see how their responses compared to the average of the rest of the respondents. Return addresses were requested from those who desired results. Anonymity and confidentiality were guaranteed. The letter was signed by the School of Industry and Technology Dean, Dr. A. Darryl Davis and this researcher. For the purposes of the study, the researcher was the "CIM Productivity Director." No allusions were made to a dissertation or to the academic orientation of the signers. The letterhead was a form of the East Carolina University letterhead. The operator's cover letter and the engineer's cover letter are shown respectively in Figures F-9 and F-10 of Appendix F.

For the engineers, the letter included the four statements that separated nonmachinists from machinists and that separated machinists from cell operators. The form was the same as that which introduced the cell operator instrument, except the spaces for checking were absent and the RJDS respondents had the statements on their survey form. Therefore, it was necessary for the engineers to remember the conditions expressed in the letter while responding to the instrument because their instrument did not have the statements that distinguished between nonmachinists, machinists, and operators. The statements were crucial in providing a common reference for responses (as to what made a person a cell operator) from the groups cell operators and engineers

The follow-up letter. The follow-up letter continued the request for return of the completed instrument while indicating the instrument color so as to aid the potential respondent in locating the instrument. The follow-up letter was on canary-colored stock so as to precipitate some curiosity and, possibly, association with the instrument. The operator's follow-up letter and the engineer's follow-up letter are shown respectively in Figures F-11 and F-12 of Appendix F.

The mail package. It was believed that getting the addressee to open the mailed package was a substantial task. As almost everyone has been inundated with everyone else's "important information enclosed," it was felt that the appearance of the mailed package must be exceptional to warrant attention. The extent of the package, a four page instrument, a cover letter, and a return envelope required a 9" X 12" envelope. Though white 9" X 12" envelopes have been more expensive, the 9" X 12" envelope used has usually been manilla such that a white 9" X 12" envelope was expected to get above-average attention. All envelopes were preprinted. No rubber stamping was used as it was felt that rubber stamping looked cheap, appeared unattractive, and hinted at poor organization. It was also felt the third class nonprofit postage mark would greatly help returns as the observant addressee would know that such a postage mark indicated that, if the enclosures were "junk mail," the enclosures were not the normal type of commercial "junk mail." In stuffing the envelopes, care was taken to assure that the self-addressed prestamped envelope was clearly visible so as to induce the respondent to read the cover letter.

Additional mailings were sent to a few people who were not subjects, but who could provide progress reports on the receipt of the mailed packages. The instruments they received were distinctly marked in the event they returned the instruments in testing the reliability of the data collection system.

Handling Returns and Data

The handling of responses was a critical aspect of the data gathering because the data gathered must not have been contaminated by the biases of the researcher. The following data handling procedures were developed with much forethought to assure that responses would not be influenced by the researcher's bias. The best approach to handling the data was to have an objective third party tabulate the data. However, this expense was beyond the means of the researcher. It was felt that the rules would have exceptions that warranted exclusion of some results normally included and some results would be included that might have been excluded by strict application of "the rules." The primary requirement for the data collection was that the results be from the intended subjects of the samples.

Logging and sorting returns. Upon receipt of daily returns, each envelope was marked with the receipt date and the difference in the number of days between the survey mailing date and the postmark cancellation date. This was done to assure discipline in the handling of returns and to make it easier to "follow the mailing." Envelopes were then opened and the first information sought was whether the instrument returned was a RJDS or a RJRF. Then the part preceding Section 1 was examined to see how the respondent checked boxes. Then the job title was checked to see if the job title confirmed the information checked in the boxes. In only a few cases, was there a need for judgment in deciding whether a return's data was usable or not. It was not deemed ethical in any cases to preview results before a decision was made. There were only four ways of classifying results for purposes of this study. A respondent, considered part of the group from which responses were desired, had his or her form put in one of two boxes. One box marked JDSC contained cell operators' returns. The second box marked JRFE contained manufacturing engineers' returns. A third box contained everything else. No returns were literally discarded as much of the information was projected as having potential for further data handling with implications for other studies. Each envelope was marked for the return that was in it. Markings were JDSC, JRFE, JDS-, and JRF-. The JDS- and JRF- designations respectively meant "JDS returned, but the respondent was not a cell operator" and "JRF returned, but the respondent was not a manufacturing engineer." It has been important to reiterate, for purposes of study replication, that no marks were placed on the returned instruments (except the date was affixed for returns after July 8, 1990). The instruments and envelopes were separated and put in boxes with no order observed. Thus, it was impossible to know who the individual respondents were or the geographical origin of each returned survey form.

Total daily returns were plotted on a bar graph and cumulative daily totals were kept for the cell operator returns (JDSC) and the manufacturing engineer returns (JRFE). It was decided to consider the returning of results phase as completed when two consecutive working days without returns elapsed. An addendum to the methodology was necessary. The June 15, 1990 cancellation requirement had to be ignored because of problems in distributing the mail. The problem and its implications have been briefly detailed in the discussion of results.

Tabulating data. In preparing to tabulate data, each returned form was numbered. There were two sets of numbers: one for cell operators and one for manufacturing engineers. The data for each return were tabulated horizontally with 32 columns provided for the 32 responses and each line had the unique identification number that was added to the respective RJDS or RJRF form. Each column then, represented the responses to one item on one instrument type. Upon completion of the tabulation, a second tabulation was made in checking the accuracy of the transcription of data. Discrepancies were checked against the specific form in question. For intrainterval responses, the only acceptable transcriptions were to the first decimal place unless, of course the respondent wrote in a specific value which was then transcribed. Upon completion of all of this activity, the results were considered ready for statistical treatment.

Statistical Analyses

There were a number of statistical tests that needed to be or should be performed in providing for credibility of the results. The *t* test for differences between sample means was the primary statistical method employed in answering the research questions.

It was considered acceptable to use samples of convenience and assume they were representative of the population unless there were reasons for suspecting results were not applicable to the population (Dominowski, 1980). Nonetheless, as this research provided a data-based model of nationwide CIM use, additional tests were made for representativeness of the samples. There were *r* correlation coefficient analyses that were used in inferring that returns comprised representative samples of the population, to which generalizations were desirable. In comparing the respondent samples to the mailed samples, the χ^2 "goodness-of-fit" test also provided another way of testing for representativeness of the samples.

Testing for Differences: Answering the Research Questions

The *t* test for differences between sample means was used 11 times in determining whether there was a significant difference (.05, two-tailed) between the responses to each of the 11 items used on the RJDS and the RJRF where the same numbered item by section on each test had its compliment on the other test. Thus, Research Questions 1 through 11 were answered in testing for significance in comparing the responses of both groups on items 1 through 11 of Section 3. Another *t* test was performed in determining the differences in perceptions of the WLGNS, which is the average of responses to Items 2, 3, 6, 8, 10, and 11 of Section 3 after 3 is subtracted from each response. This answered Research Question 12.

What was the sample size used in calculating the cell operator's WLGNS? The sample size had to equal the number of all respondents who answered all six items that comprised the WLGNS as on an individual basis it was said that a subject not responding to one or more of the six items did not have a calculable WLGNS. In determining the WLGNS it was not acceptable to find the overall group averages for each of the six growth needs that comprised the WLGNS and then calculate a WLGNS for an "average" respondent.

The final test, unlike the tests where only sample data were available, used sample data for the cell operators and population data for the bench workers in answering Research Question 13. The only test that was available was Hackman and Oldham's "quite discrepant" two sigma test. The summary of that test was that any mean more than two standard deviations from the group mean was considered significant or "quite discrepant." The $\underline{t}$ tests could not have been used as the scores of both groups specifically pertained to each group and not to the evaluation by both groups of the score of any other group. In using the mean scores, an "average" bench worker was considered as the group's mean which was compared to the mean of the cell operators' group with its complimentary range of scores derived from the two sigma limit. Then it was determined whether the bench worker "fitted in" with the cell operators' group. In a complementary fashion, an average cell operator was compared to the bench worker group to see if the cell operator "fitted in" with that group.

Testing for Differences: Historical Changes

As a result of receiving returns from respondents who were not cell operators, but were machinists, additional testing was available because the machinists' WLGNS sample mean and standard deviation were known. Machinists could have been called "machine trades" and the machine trades' WLGNS and population standard deviation were available (Hackman & Oldham, 1980, p. 317). A simple $\underline{t}$ test was made in determining if the machine trades needs had changed significantly (.05, two-tailed) since 1979. The results of this test should have indicated what changes in needs had been experienced by machinists in 11 years. As there were less than 30 respondents in this group, a normal distribution was assumed.

The Correlation Test for Representativeness

The *r* correlation coefficient was determined from a comparison of the number of returns per state to the number of establishments having 1000 or more employees and making products with SIC codes 35 or 37. This derivation with its complementary significance test ($p < .05$, one-tailed), was calculated for each of the two samples cell operators and manufacturing engineers. The variables of interest were paired by each state surveyed such that $N_{\text{cell operators}} = 43$ and $N_{\text{engineers}} = 41$. The reasoning behind the comparisons was: The determination of the criteria for the number of plants was the probability of being involved with CIM by having size and process propensities. The derivation of the original mailing lists came from subscriptions to magazines with subject matter that was oriented heavily toward automated manufacturing technology (AMT). The subscribers apparently had AMT propensities. It appeared to follow, that two indicators of CIM and/or AMT correlated highly if the samples of occupations and the population of sites did indeed follow a CIM and/or AMT orientation. Of course, there were other possibilities, but the site criteria were established with the intention of finding AMT indicators which was not the same as finding a fit that then needs an explanation. Thus, the explanation that high correlation was an indication of the presence of CIM was the "best fit" choice.

In a similar manner, *r* correlation analyses were used in determining if the samples of returns were representative of the mailed samples. The frequency counts were compared by state for the mailed sample and the returned sample for the cell operators and the engineers ($\underline{N}_{\text{cell operators}}$ = 40 states, $\underline{N}_{\text{engineers}}$ = 40 states). It is noted that the 40 states from which responses were received from one group were not the same 40 states from which responses were received from the other group.

The "Goodness-of-Fit" Test for Representativeness

The χ^2 "goodness-of-fit" test provided a way of determining if a distribution was representative. The frequency counts, by geographic area, of respondents and those on the mailing list were compared. If a significant difference was found between the two groups, it was assumed the respondents were not representative of the group. This test was conducted for each of the two groups cell operators and manufacturing engineers. Figure 9 shows the variables used in the χ^2 "goodness-of-fit" tests.

$\underline{A}$ = number of units returned from each area.

$\underline{E}$ = expected number of returns from each area.

$\underline{C}$ = number of units mailed to each area.

$\underline{N}_e$ = total number of units mailed.

$\underline{N}_o$ = total number of units returned.

$\underline{N}$ = Number of geographic areas.

Figure 9. χ^2 "goodness-of-fit" test variables.

The "Goodness-of-Fit" Test for Determining Distribution Normality

The χ^2 "goodness-of-fit" test was used to determine if a distribution was normal by comparing the observed category counts to expected category counts of a normal distribution. The actual counts were placed in intervals. Each interval had an expected normal distribution count associated with it that was compared to the actual interval count.

Postdata Collection Design

Data collection revealed that, in general, the responses to the items were not distributed normally. The t tests were performed to remove doubt concerning significant differences in assuming that the data distributions were only moderate permutations of normal distributions. Each research question treatment had a bar graph of the frequency distribution and a table of the results of the t test for differences between sample means.

The χ^2 "goodness-of-fit" test for determining representativeness performed on the returned sample in comparing it to the mailed sample was also employed in determining if responses of manufacturing engineers were significantly different from responses of cell operators. Where samples were shown to be not normally distributed, this test was the major test of a null hypothesis in determining significance. The responses of the cell operators (N_{oc}) in each chosen interval were used in determining the expected responses of the engineers (N_{ee}) within the same intervals. Of course, the observed engineers' responses were used in each chosen interval in finding ($\underline{E}_e$ - $\underline{A}_e$). The $\underline{t}$ test was just "another view" of the results when the distribution was not normally distributed. Where samples appeared to be normally distributed, the $\underline{t}$ test was the major test of a null hypothesis in determining significance. The χ^2 "goodness-of-fit" test was just another view of the results when results appeared to be normally distributed. Where the responses of one group were considered normal while the responses of the other group were found to be distribution-free, the χ^2 "goodness-of-fit" was used as the major test of the null hypothesis. Analyses of variance were added in extending the usefulness of the data.

CHAPTER 4

THE REPORT OF RESULTS

The findings of this study were treated in three sections: The first section examined representativeness of the samples. The second section examined the research questions. The third section provided the cell operator core job characteristics profile and the operator's motivating potential score (MPS).

Sample Representativeness

The following analyses are provided in answering the question: Are the samples representative of the population? Also: Can the results be generalized to the populations of cell operators and manufacturing engineers?

In this section the representativeness of samples was examined through two approaches. One approach used the determination of r correlation coefficients where positive correlation was desired. For returned samples, the additional χ^2 "goodness-of-fit" tests were performed in examining changes from the sample surveyed and the sample of responses received.

Cell Operator Samples

Appendix G, Table G-1, shows the plant site counts and mailed cell operator counts. The r correlation coefficient, +.90, was significant at the .005 level. When states with zero fequencies were deleted, the r correlation coefficient, +.89, was significant at the .005 level. Table G-2, shows the plant site counts and mailed cell operator counts without the zero frequencies. Appendix G, Table G-3, shows the mailed cell operator counts and cell operator returns. The *r* correlation coefficient, +.84, was significant at the .005 level. When states with zero frequencies were deleted, the *r* correlation coefficient, +.82, was significant at the .005 level. Appendix G, Table G-4, shows the mailed cell operator counts and cell operator returns without the zero frequencies.

Appendix G, Table G-5, shows the grouped data for the χ^2 "goodness-of-fit" test performed. Table G-5 was developed by first considering the number of groups needed. As there were 46 returns, five groups were desired ($2^5 < 46$). There was then an attempt to group states by geographic considerations that would appear to make some sense in being compatible with CIM site locations. This resulted in grouping states by their being adjacent to each other such that each group would appear as a block. Also, it was desirable to respect mountains as mountains can offer distinct economic and industrial development divisions. There were exceptions to both considerations as a perfectly acceptable fit did not appear possible. It was also desirable to have the mailing counts not too different between groups. Group counts resulted in a range of 40 to 96. Of the 284 subjects of the mailing, 46 identified as cell operators responded for a 16.2% response rate. The test results are displayed in Table 1. It appeared the respondents were representative of the group on the mailing list.

Table 1

Cell Operator "Goodness-of-Fit" Test for Representativeness

Counts	Alabam Group	Arizona Group	Arkansa Group	Connecti Group	Illinois Group	Total
Observe	10	11	5	6	14	46
Expect	6.6	10.7	6.5	6.6	15.5	45.9

$\chi^2 = 2.31$; $p > .05$; not significant

Manufacturing Engineer Samples

Appendix G, Table G-6, shows the plant site counts and mailed manufacturing engineer counts. The r correlation coefficient, +.80, was significant at the .05 level. When states with zero frequencies were deleted, the r correlation coefficient, +.80, was significant at the .05 level. Appendix G, Table G-7, shows the plant site counts and mailed manufacturing engineer counts without zero frequencies. Appendix G, Table G-8, shows the mailed manufacturing engineer counts and manufacturing engineer returns. The r correlation coefficient, +.86, was significant at the .05 level. When states with zero frequencies were deleted, the r correlation coefficient, +.87, was significant at the .05 level. Appendix G, Table G-9, shows the mailed manufacturing engineer counts and manufacturing engineer returns without zero frequencies.

Appendix G, Table G-10, shows the grouped data for the χ^2 "goodness-of-fit" test performed. The same general grouping developed for Table G-5 was also used for Table G-10. It was believed that, once groups were identified for Table G-5 using logic based on a CIM relationship, the same grouping should be used for Table G-10 because the CIM relationship was the common denominator for the study. The term "general" is used in general grouping because the group compositions vary between the cell operator mailing and the engineer mailing. It is emphasized that any state in a group in Table G-5 is in the same group in Table G-10 and vice versa or it is not in any other group. Of the 589 subjects of the mailing, 158 identified as manufacturing engineers responded for a 26.8% response rate. Only 146 responses were shown as some returns had no postmark or the mark was unreadable. The test results are displayed in Table 2. It was acceptable to assume the respondents represented the group on the mailing list.

Table 2

Engineer "Goodness-of-Fit" Test for Representativeness

Counts	Florida Group	Arizona Group	Arkansa Group	Connecti Group	Illinois Group	Total
Observe	14	32	11	33	56	146
Expect	9.4	34.2	13.1	37.4	51.8	145.9

$\chi^2 = 3.59$; $p > .05$; not significant

The Research Questions

This section examined answering the research questions. Each of the first 12 questions was treated in a separate subsection that included a composite bar graph, χ^2 "goodness-of-fit" test in checking for a normal distribution, *t* test for differences between sample means, and χ^2 "goodness-of-fit" test for examining differences between the groups, cell operators and manufacturing engineers. Question 13 required a "quite discrepant" test comparing the two groups, bench workers and cell operators. A χ^2 "goodness-of-fit" test was not performed as the distribution of data for the bench workers was not available. Hackman and Oldham (1980) suggested that scores more than two standard deviations from the sample means reported in their book, Work Redesign, were to be considered "quite discrepant" (p. 316). That simple comparison was used as a test of significance.

In establishing a reference between the past (1980) and the present, when no new bench worker mean and standard deviation values were available, the bench worker values also were compared to the machine trades mean and standard deviation of 1980 and to the machinist mean and standard deviation, available from this study. Such comparisons provided some continuity of measurement over time through the machine trades' of 1980 being considered by job as comparable to the machinists of 1990.

The data acquired in answering the first 11 research questions required that the respondent read each statement of the revised Job

Diagnostic Survey (RJDS) or the revised Job Rating Form (RJRF) and then refer to the scale shown in Figure 10 in choosing a response number. For each statement, the respondent chose how much he or

4	5	6	7	8	9	10
Would like having this only a moderate amount (or less)			Would like having this very much			Would like having this extremely much

Figure 10. RJDS/RJRF section 3 rating scale.

she as a cell operator desired the characteristic or how much he or she as an engineer believed the cell operator desired the characteristic.

Research Question 1

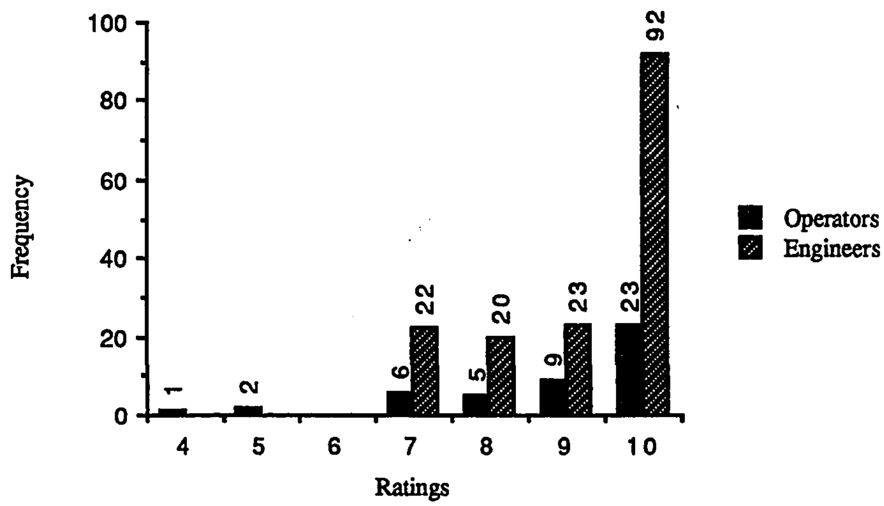
Research Question 1 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for high respect and fair treatment from their supervisors?" This was transformed from the first statement requiring a response of Section 3 for the RJDS and the RJRF respectively:

_____ 1. High respect and fair treatment from my supervisor.

_____ 1. High respect and fair treatment from his or her supervisor.

<u>Analysis of variance</u>. The analysis of variance permutation of Research Question 1 was "In predicting the desire of the cell operator for high respect and fair treatment from his or her supervisor, do the cell operators' responses vary more than the manufacturing engineers' responses?"

<u>The tests</u>. Figure 11 shows the responses by category (rating) for each group of respondents. Tables 3, 4, 5, 6, and 7 show respectively the results of testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the *t* test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant



<u>Figure 11</u>. Cell operators and engineers section 3, item 1 response distribution.

Table 3

Cell Operator Section 3, Item 1 Distribution Test

Counts	Scale $\underline{x}$ =< 6.5	Scale 6.5 < $\underline{x}$< 7.5	Scale 7.5 < $\underline{x}$ <8.5	Scale 8.5 < $\underline{x}$ < 9.5	Scale 9.5 < $\underline{x}$	Total
Observe	3	6	5	9	23	46
Expect	2.9	5.8	10.2	11.7	15.4	46

χ^2 (4, $\underline{N}_{oc} = \underline{N}_{ec}$ = 46) = 7.03; $\underline{p}$ > .05; not significant

difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 6, the cell operators' responses were used as the base and template in determining the expected counts. The observed responses were manufacturing engineers' responses.

Table 4

Engineer Section 3, Item 1 Distribution Test

Counts	Scale Responses $\underline{x}$ <7.5	Scale Responses 7.5 < $\underline{x}$ < 8.5	Scale Responses 8.5 < $\underline{x}$ < 9.5	Scale Responses 9.5 < $\underline{x}$	Total
Observed	22	20	23	92	157
Expected	10.2	32.2	53.9	60.8	157.1

χ^2 (3, $\underline{N}_{oe} = \underline{N}_{ee}$ = 157) = 52.00; $\underline{p}$ < .001; significant

Table 5

Cell Operator and Engineer Section 3, Item 1 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	8.85	1.55
RJRF	157	9.18	1.12
$SD_{ce} = .21$; $t_{ce}(201) = -1.57$; $p > .05$; not significant			

Table 6

Cell Operator and Engineer Section 3, Item 1 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale $x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observe (Eng)	0	22	20	23	92	157
Expect (Oper)	10.2	20.5	17.1	30.7	78.5	157
χ^2 (4, $N_{ec} = 46$, $N_{oe} = 157$) = 15.05; $p < .005$; significant						

Results. The cell operators' responses were considered normally distributed while the engineers' responses were not normally distributed. Results of the t test for differences between sample means indicated cell operators and manufacturing engineers did not

Table 7

Section 3, Item 1 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	2.40
Manufacturing Engineers	1.25
F (45, 156) = 1.92; $p < .01$; significant	

differ significantly in their mean ratings of the cell operators' desire for high respect and fair treatment from their supervisors. Both groups rated this desire very highly ($M_c = 8.85$; $M_e = 9.18$). The χ^2 "goodness-of-fit" test indicated the distributions of responses for cell operators and manufacturing engineers were significantly different ($p < .005$). The cell operators' responses varied significantly more ($p < .01$) than the engineers' responses.

Research Question 2

Research Question 2 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for stimulating and challenging work?" This was transformed from the second statement of Section 3 requiring a response for both the RJDS and the RJRF:

_____ 2. Stimulating and challenging work.

Analysis of variance. The analysis of variance permutation of Research Question 2 was "In predicting the desire of the cell operator for stimulating and challenging work, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 12 shows the responses by category (rating) for each group of respondents. Tables 8, 9, 10, 11, and 12 show

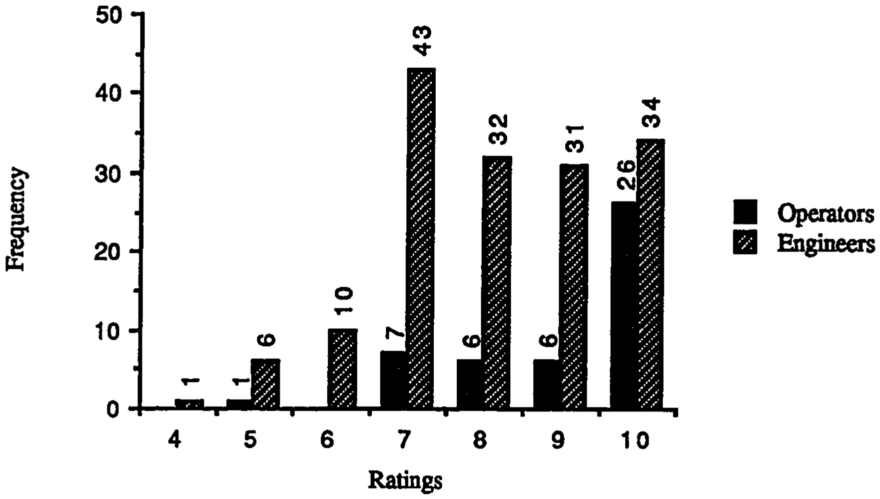


Figure 12. Cell operators and engineers section 3, item 2 response distribution.

respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the t test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in

Table 8

Cell Operator Section 3, Item 2 Distribution Test

Counts	Scale $x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observe	1	7	6	6	26	46
Expect	1.1	4.1	10.3	14.0	16.6	46.1

χ^2 (4, $N_{oc} = N_{ec} = 46$) = 13.75; $p < .01$; significant

Table 9

Engineer Section 3, Item 2 Distribution Test

Counts	Scale $x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observ	7	10	43	32	31	34	157
Expect	5.3	15.2	32.7	43.2	35.5	25.1	157

χ^2 (5, $N_{oe} = N_{ee} = 157$) = 12.20; $p < .05$; significant

the distribution of responses provided for each scale category. In Table 11, the cell operators' responses were used as the base and the template in determining the expected counts. The observed responses were engineers' responses.

Table 10

Cell Operator and Engineer Section 3, Item 2 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	9.04	1.30
RJRF	157	8.09	1.43
SD_{ce} = .23; t_{ce} (201) = 4.13; p < .01; significant			

Table 11

Cell Operator and Engineer Section 3, Item 2 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale $x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observe (Eng)	17	43	32	31	34	157
Expect (Oper)	3.4	23.9	20.5	20.5	88.7	157
χ^2 (4, N_{oc} = 46, N_{ee} = 157) = 115.22; p < .001; significant						

Results. Both groups' responses were not considered normally distributed. Results of the t test for differences between sample means indicate there was a significant difference (p < .01) between

Table 12

Section 3, Item 2 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	1.69
Manufacturing Engineers	2.04
F (45, 156) = 1.21; $p > .05$; not significant	

the cell operators and manufacturing engineers in their mean ratings (M_c = 9.04; M_e = 8.09) of the cell operator's desire for stimulating and challenging work. The χ^2 "goodness-of-fit" test indicated the distribution of responses between the groups was significantly different (p < .001). Though the smaller group was the cell operators, the variance was higher for the engineers, but it was not significant. While 41% of the engineers attributed the cell operators with their desired level or higher (9 and 10) of challenging and stimulating work, 70% of the operators chose the level at 9 or 10.

Research Question 3

Research Question 3 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for chances to exercise independent thought and action in their jobs?" This was transformed from the third statement of Section 3 that required a response for the RJDS and the RJRF respectively:

_____ 3. Chances to exercise independent thought and action in my job.

_____ 3. Chances to exercise independent thought and action in his or her job.

Analysis of variance. The analysis of variance permutation of Research Question 3 was "In predicting the desire of the cell operator for chances to exercise independent thought and action in his or her job, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 13 shows the responses by category (rating) for each group of respondents. Tables 13, 14, 15, 16, and 17 show

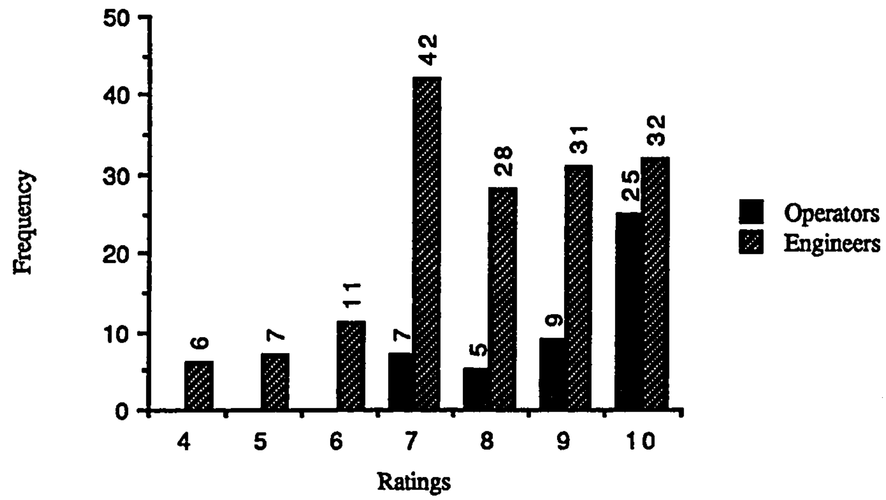


Figure 13. Cell operators and engineers section 3, Item 3 response distribution.

respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the t test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In

Table 13

Cell Operator Section 3, Item 3 Distribution Test

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed	7	5	9	25	46
Expected	3.4	9.8	15.7	17.1	46
χ^2 (3, $N_{oc} = N_{ec}$ = 46) = 12.67; $p < .01$; significant					

Table 14

Engineer Section 3, Item 3 Distribution Test

Count	Scale $x < 4.5$	Scale $4.5 < x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Obser	6	7	11	42	28	31	32	157
Expect	2.7	7.7	19.3	33.0	38.5	30.8	25.1	157.1
χ^2 (6, $N_{oe} = N_{ee}$ = 157) = 14.87; $p < .025$; significant								

Table 15

Cell Operator and Engineer Section 3, Item 3 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	9.13	1.13
RJRF	157	7.91	1.61
$SD_{ce} = .25$; $t_{ce}(201) = 4.88$; $p < .01$; significant			

Table 16

Cell Operator and Engineer Section 3, Item 3 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed (Engineer)	66	28	31	32	157
Expected (Operator)	23.9	17.1	30.7	85.3	157
χ^2 (3, $N_{oc} = 46$, $N_{ee} = 157$) = 114.41; $p < .001$; significant					

Table 16, the cell operators' responses were used as a base and as the template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Table 17

Section 3, Item 3 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	1.28
Manufacturing Engineers	2.59
F (45, 156) = 2.02; $p < .01$; significant	

Results. Neither group had normally distributed responses. The t test for differences between sample means indicated there was a significant difference between mean ratings of cell operators and manufacturing engineers ($p < .01$; $M_c = 9.13$; $M_e = 7.91$) in their ratings of the cell operators' desire for chances to exercise independent thought and action in their jobs. The χ^2 "goodness-of-fit" test indicated there was a significant difference ($p < .001$) between cell operators and manufacturing engineers in their distribution of responses. The modal distribution was seven for manufacturing engineers and 10 for the cell operators. The variance was significantly higher for the larger group, manufacturing engineers ($p < .01$). Whereas, the cell operators as a group (54%) scored this characteristic at 9 or 10, only 40% of the engineers scored the characteristic at 9 or 10.

Research Question 4

Research Question 4 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for great job security?" This was transformed from the fourth statement requiring a response of Section 3 for both the RJDS and the RJRF:

_____ 4. Great job security.

Analysis of variance. The analysis of variance permutation of Research Question 4 was "In predicting the desire of the cell operator for great job security, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 14 shows the responses by category (rating) for each group of respondents. Tables 18, 19, 20, 21, and 22 show

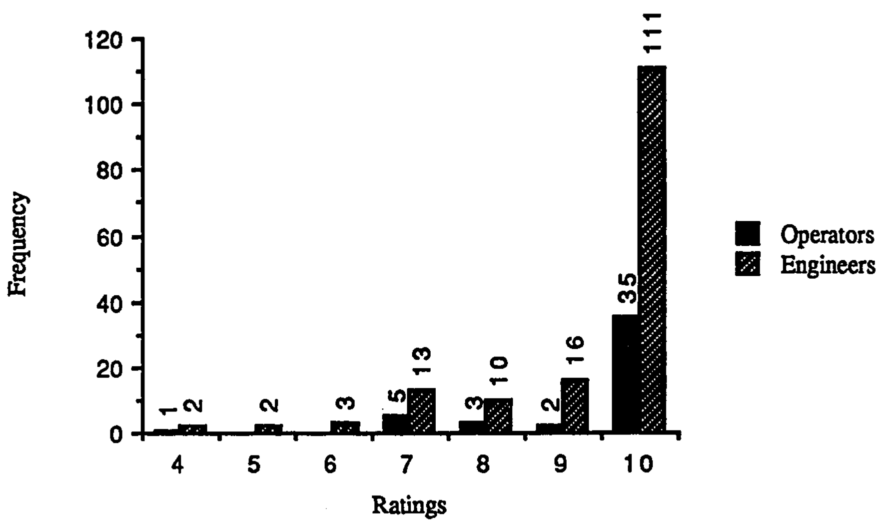


Figure 14. Cell operators and engineers section 3, item 4 response distribution.

respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the *t* test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In

Table 18

Cell Operator Section 3, Item 4 Distribution Test

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed	6	3	2	35	46
Expected	3.4	8.1	13.3	21.2	46

χ^2 (3, $N_{oc} = N_{ec} = 46$) = 23.78; $p < .001$; significant

Table 19

Engineer Section 3, Item 4 Distribution Test

Counts	Scale $x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observe	7	13	10	16	111	157
Expect	2.4	10.5	29.1	45.7	69.4	157.1

χ^2 (4, $N_{oe} = N_{ee} = 157$) = 66.20; $p < .001$; significant

Table 20

Cell Operator and Engineer Section 3, Item 4 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	9.37	1.31
RJRF	157	9.31	1.31

$SD_{ce} = .25$; $t_{ce}(201) = .24$; $p > .05$; not significant

Table 21

Cell Operator and Engineer Section 3, Item 4 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale $x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observe (Eng)	7	13	10	16	111	157
Expect (Oper)	3.4	17.1	10.2	6.8	119.5	157

$\chi^2 (4, N_{ec} = 46, N_{oe} = 157) = 17.84$; $p < .005$; significant

Table 21, the cell operators' responses were used as the base and the template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Table 22

Section 3, Item 4 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	1.72
Manufacturing Engineers	1.72
F (45, 156) = 1.00; p > .05; not significant	

Results. The responses of both groups were not considered normally distributed. As the means and standard deviations of the groups were effectively the same (M_c = 9.37; M_e = 9.31; SD_c = SD_e = 1.31), the t test for differences between sample means obviously indicated there was no significant difference between the mean ratings of both groups of the cell operator's desire for great job security. However, the χ^2 "goodness-of-fit" test indicated the distribution of responses between the groups was significantly different (p < .005). The engineers' responses did not vary significantly more than the cell operators' responses. Of the cell operators, 80% responded 9 or 10 while 81% of the engineers responded 9 or 10.

Research Question 5

Research Question 5 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for very friendly coworkers?" This was transformed from the fifth statement requiring a response of Section 3 for both the RJDS and the RJRF:

_____ 5. Very friendly co-workers.

Analysis of variance. The analysis of variance permutation of Research Question 5 was "In predicting the desire of the cell operator for very friendly coworkers, do the cell operators' responses vary more than the manufacturing engineers' responses?"

The tests. Figure 15 shows the responses by category (rating) for each group of respondents. Tables 23, 24, 25, 26 and 27 show

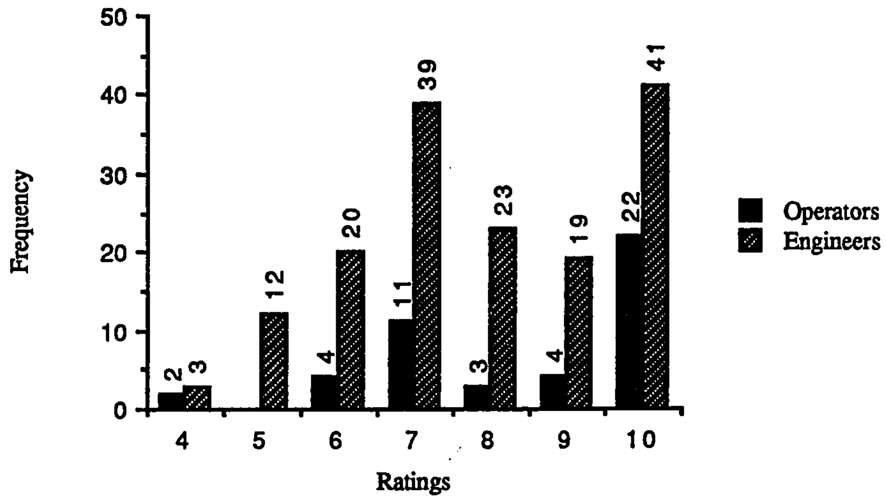


Figure 15. Cell operators and engineers section 3, item 5 response distribution.

respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the t test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In

Table 23

Cell Operator Section 3, Item 5 Distribution Test

Counts	Scale $x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observ	2	4	11	3	4	22	46
Expect	2.1	4.0	7.4	10.0	9.9	12.7	46.1

χ^2 (5, $N_{oc} = N_{ec} = 46$) = 16.98; $p < .005$; significant

Table 24

Engineer Section 3, Item 5 Distribution Test

Count	Scale $x < 4.5$	Scale $4.5 < x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Obser	3	12	20	39	23	19	41	157
Expect	3.9	9.4	20.7.	32.3	36.1	28.9	25.6	156.9

χ^2 (6, $N_{oe} = N_{ee} = 157$) = 19.74; $p < .005$; significant

Table 25

Cell Operator and Engineer Section 3, Item 5 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	8.46	1.77
RJRF	157	7.83	1.71

$SD_{ce} = .29$; $t_{ce}(201) = 2.17$; $p < .05$; significant

Table 26

Cell Operator and Engineer Section 3, Item 5 "Goodness-of-Fit" Test for the Distribution of Responses

Counts	Scale $x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observ (Eng)	15	20	39	23	19	41	157
Expect (Oper)	6.8	13.7	37.5	10.2	13.7	75.1	157

$\chi^2 (5, N_{ec} = 46, N_{oe} = 157) = 46.44$; $p < .001$; significant

Table 26, the cell operators' responses were used as the base and as the template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Table 27

Section 3, Item 5 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	3.13
Manufacturing Engineers	2.92
F (45, 156) = 1.07; $p > .05$; not significant	

Results. Both groups' responses were not considered normally distributed. Results of the t test for differences between sample means indicated the mean ratings of cell operators and manufacturing engineers were significantly different ($p < .05$; $M_c = 8.46$; $M_e = 7.83$) in their rating of the cell operator's need for very friendly coworkers. The χ^2 "goodness-of-fit" test indicated the distribution of responses between the groups was significantly different ($p < .001$). The cell operators' responses did not vary more than the engineers' responses. Though both groups had the same mode of 10, there was a minor mode of seven for both groups. However, only half as many operators were at the minor mode as compared to the actual mode (11:22) while the engineers minor mode was effectively equal to the actual mode (39:41).

Research Question 6

Research Question 6 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for opportunities to learn new things from their work?" This was transformed from the sixth statement requiring a response of Section 3 for the RJDS and the RJRF respectively:

_____ 6. Opportunities to learn new things from my work.

_____ 6. Opportunities to learn new things from his or her work.

Analysis of variance. The analysis of variance permutation of Research Question 6 was "In predicting the desire of the cell operator for opportunities to learn new things from his or her work, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 16 shows the responses by category (rating) for each group of respondents. Tables 28, 29, 30, 31, and 32 show

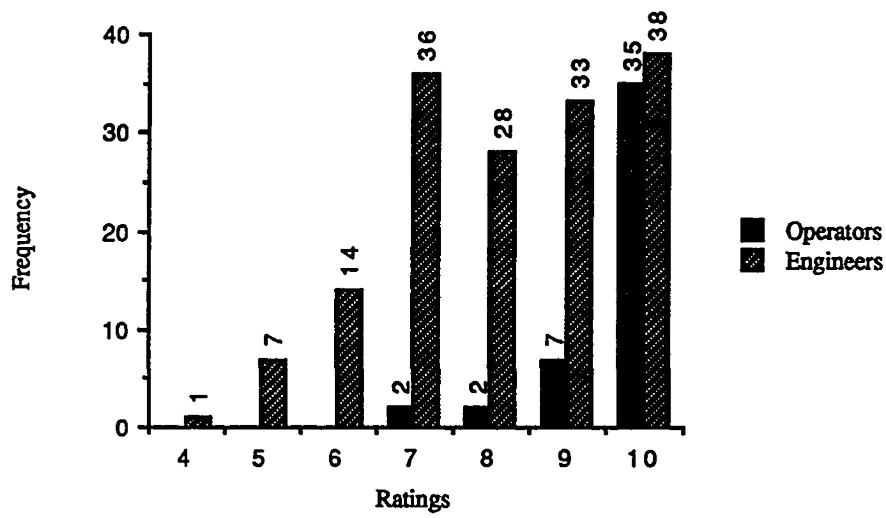


Figure 16. Cell operators and engineers section 1, item 6 response distribution.

respectively the testing for cell operators (RJDS) distribution normality, the testing for manufacturing engineers (RJRF) distribution normality, the *t* test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators (RJDS) and manufacturing engineers (RJRF) in the distribution of responses provided for each scale category. In Table 31, the cell operators'

Table 28

Cell Operator Section 3, Item 6 Distribution Test

Counts	Scale Responses $x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed	4	7	35	46
Expected	3.2	16.7	26.1	46

χ^2 (2, $N_{oc} = N_{ec} = 46$) = 8.86; $p < .025$; significant

responses were used as base and as a template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Results. The cell operators' responses were not normally distributed, but the engineers' responses were considered normally

Table 29

Engineer Section 3, Item 6 Distribution Test

Count	Scale $\underline{x} < 4.5$	Scale $4.5 < \underline{x} < 5.5$	Scale $5.5 < \underline{x} < 6.5$	Scale $6.5 < \underline{x} < 7.5$	Scale $7.5 < \underline{x} < 8.5$	Scale $8.5 < \underline{x} < 9.5$	Scale $9.5 < \underline{x}$	Total
Obser	1	7	14	36	28	33	38	157
Expect	1.3	5.0	15.5	31.1	40.8	34.9	28.4	157

χ^2 (6. $\underline{N}_{oe} = \underline{N}_{ee} = 157$) = 9.16; $\underline{p} > .05$; not significant

Table 30

Cell Operator and Engineer Section 3, Item 6 t Test for Differences between Sample Means

Form	$\underline{N}$	$\underline{M}$	$\underline{SD}_{sample}$
RJDS	46	9.63	.77
RJRF	157	8.13	1.50

$\underline{SD}_{ce} = .23$; $\underline{t}_{ce}$ (201) = 6.52; $\underline{p} < .01$; significant

distributed. Results of the $\underline{t}$ test for differences between sample means indicated there was a significant difference ($\underline{p} < .01$) between cell operators and engineers in their mean ratings of the cell operator's desire for opportunities to learn new things from their work ($\underline{M}_c = 9.63$; $\underline{M}_e = 8.13$). The χ^2 "goodness-of-fit" test indicated the distribution of responses between operators and engineers were

Table 31

Cell Operator and Engineer Section 3, Item 6 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed (Engineer)	58	28	33	38	157
Expected (Operator)	6.8	6.8	23.9	119.5	157

χ^2 (3, N_{ec} = 46, N_{oe} = 157) = 510.64; $p < .001$; significant

Table 32

Section 3, Item 6 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	.59
Manufacturing Engineers	2.25

F (45, 156) = 3.81; $p < .01$; significant

significantly different ($p < .001$). The engineers had a significantly larger response variance than the cell operators ($p < .01$). The standard deviation of the engineers was almost twice that of the cell operators (SD_e = 1.50, SD_c = .77).

Research Question 7

Research Question 7 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for high salary and good fringe benefits?" This was transformed from the seventh statement requiring a response of Section 3 for both the RJDS and the RJRF:

_____ 7. High salary and good fringe benefits.

Analysis of variance. The analysis of variance permutation of Research Question 7 was "In predicting the desire of the cell operator for high salary and good fringe benefits, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 17 shows the responses by category (rating) for each group of respondents. Tables 33, 34, 35, 36, and 37 show respectively the testing for cell operators (RJDS) distribution normality, the testing for manufacturing engineers (RJRF) distribution normality, the *t* test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 36, the cell operators' responses were used as a base and as a template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Results. Both groups' responses were not considered normally distributed. Results of the *t* test for differences between sample

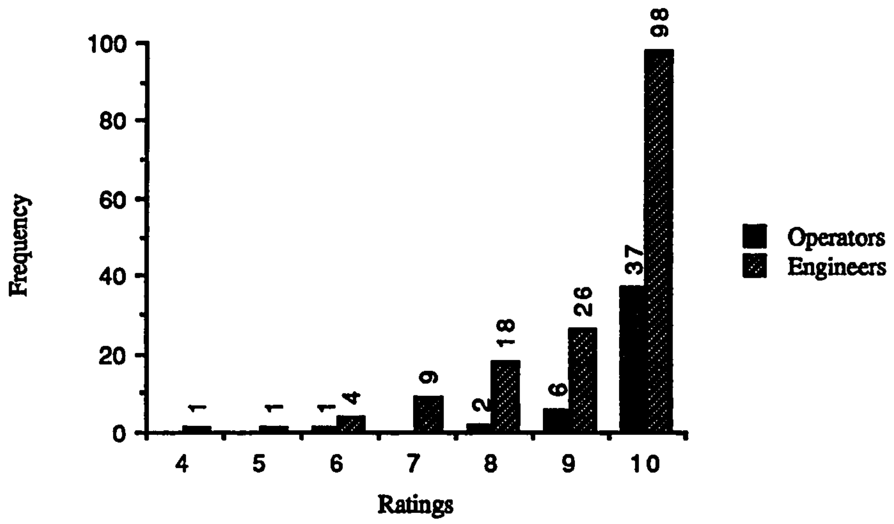


Figure 17. Cell operators and engineers section 3, item 7 response distribution.

Table 33

Cell Operator Section 3, Item 7 Distribution Test

Counts	Scale Responses $x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed	3	6	37	46
Expected	2.5	15.6	27.8	45.9

χ^2 (2, $N_{oc} = N_{ec} = 46$) = 9.05; $p < .025$; significant

Table 34

Engineer Section 3, Item 7 Distribution Test

Counts	Scale $\underline{x} < 6.5$	Scale $6.5 < \underline{x} < 7.5$	Scale $7.5 < \underline{x} < 8.5$	Scale $8.5 < \underline{x} < 9.5$	Scale $9.5 < \underline{x}$	Total
Observe	6	9	18	26	98	157
Expect	1.6	9.1	30.1	50.4	65.8	157

χ^2 (4, $\underline{N}_{oe} = \underline{N}_{ee}$ = 157) = 44.53; $\underline{p} < .001$; significant

Table 35

Cell Operator and Engineer Section 3, Item 7 t Test for Differences between Sample Means

Form	$\underline{N}$	$\underline{M}$	$\underline{SD}_{sample}$
RJDS	46	9.70	.76
RJRF	157	9.26	1.18

$\underline{SD}_{ce}$ = .18; $\underline{t}_{ce}$ (201) = 2.44; $\underline{p} < .02$; significant

means indicated a significant difference ($\underline{p} < .02$) between the operators' and the engineers' mean ratings of the cell operator's desire for high salary and good fringe benefits ($\underline{M}_c$ = 9.70; $\underline{M}_e$ = 9.26). The χ^2 "goodness-of-fit" test indicated the distribution of responses between operators and engineers were significantly different ($\underline{p} < .001$). The variance between the cell operators' responses and the engineers' responses was significantly different

Table 36

Cell Operator and Engineer Section 3, Item 7 "Goodness-of-Fit" Test for Differences in Distribution of Responses

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed (Engineer)	15	18	26	98	157
Expected (Operator)	3.4	6.8	20.5	126.3	157

χ^2 (3, N_{oc} = 46, N_{ee} = 157) = 65.85; $p < .001$; significant

Table 37

Section 3, Item 7 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	.58
Manufacturing Engineers	1.39

F (45, 156) = 2.40; $p < .01$; significant

($p < .01$). The modal response of the operators was 10 accounting for 80% of the responses. The mode of the engineers was also 10, but only 62% of the engineers responded with 10.

Research Question 8

Research Question 8 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for opportunities to be creative and imaginative in their work?" This was transformed from the eighth statement requiring a response of Section 3 for the RJDS and the RJRF respectively:

_____ 8. Opportunities to be creative and imaginative in my work.

_____ 8. Opportunities to be creative and imaginative in his or her work.

Analysis of variance. The analysis of variance permutation of Research Question 8 was "In predicting the desire of the cell operator for opportunities to be creative and imaginative in his or her work, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 18 shows the responses by category (rating) for each group of respondents. Tables 38, 39, 40, 41, and 42 show respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the *t* test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 41, the cell operators' responses were used as a base and as a template in determining the expected counts. The actual responses were manufacturing engineers' responses.

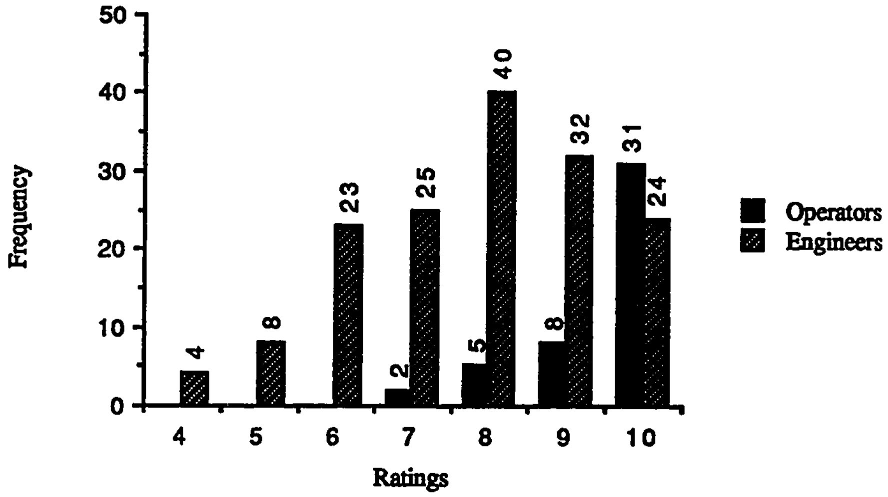


Figure 18. Cell operators and engineers section 3, item 8 response distribution.

Table 38

Cell Operator Section 3, Item 8 Distribution Test

Counts	Scale Responses $x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed	7	8	31	46
Expected	5.7	17.7	22.6	46

χ^2 (2, $N_{oc} = N_{ec} = 46$) = 8.74; $p < .025$; significant

Table 39

Engineer Section 3, Item 8 Distribution Test

Count	Scale $x < 4.5$	Scale $4.5 < x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Obser	4	8	23	25	40	32	24	156
Expect	2.7	8.1	20.6	34.6	39.2	29.6	21.2	156

χ^2 (6, $N_{oe} = N_{ee}$ = 156) = 4.15; $p > .05$; not significant

Table 40

Cell Operator and Engineer Section 3, Item 8 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	9.48	.86
RJRF	156	7.80	1.56

SD_{ce} = .24; t_{ce} (201) = 7.00; $p < .01$; significant

Results. The cell operators' responses were not normally distributed, but the engineers' responses were considered normally distributed. Results of the t test for differences between sample means showed a significant difference ($p < .01$) between the cell operators' and the engineers' mean ratings of the cell operator's need for creative and imaginative work (M_c = 9.48; M_e = 7.80). The χ^2

Table 41

Cell Operator and Engineer Section 3, Item 8 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed (Engineer)	60	40	32	24	156
Expected (Operator)	6.8	17.0	27.1	105.1	156
χ^2 (3, N_{ec} = 46, N_{oe} = 156) = 510.80; $p < .001$; significant					

Table 42

Section 3, Item 8 Analysis of Variance

Group	($SD_{sample}{}^2$)
Cell Operators	.74
Manufacturing Engineers	2.43
F (45, 155) = 3.28; $p < .01$; significant	

"goodness-of-fit" test indicated the distributions of responses between operators and engineers were significantly different ($p <$ .001). The variance between engineers' and cell operators' responses was significant ($p < .01$). The modal response of the cell operators was 10 with 67% of the responses. The modal response of the engineers was eight with 25% of the responses.

Research Question 9

Research Question 9 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for quick promotions?" This was transformed from the ninth statement requiring a response of Section 3 for both the RJDS and the RJRF:

_____ 9. Quick promotions.

Analysis of variance. The analysis of variance permutation of Research Question 9 was "In predicting the desire of the cell operator for quick promotions, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 19 shows the responses by category (rating) for each group of respondents. Tables 43, 44, 45, 46, and 47 show respectively the testing for cell operators (RJDS) distribution normality, the testing for manufacturing engineers (RJRF) distribution normality, the *t* test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 46, the cell operators' responses were used a base and as a template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Results. The cell operators' responses were not considered different from a normal distribution while the engineers' responses

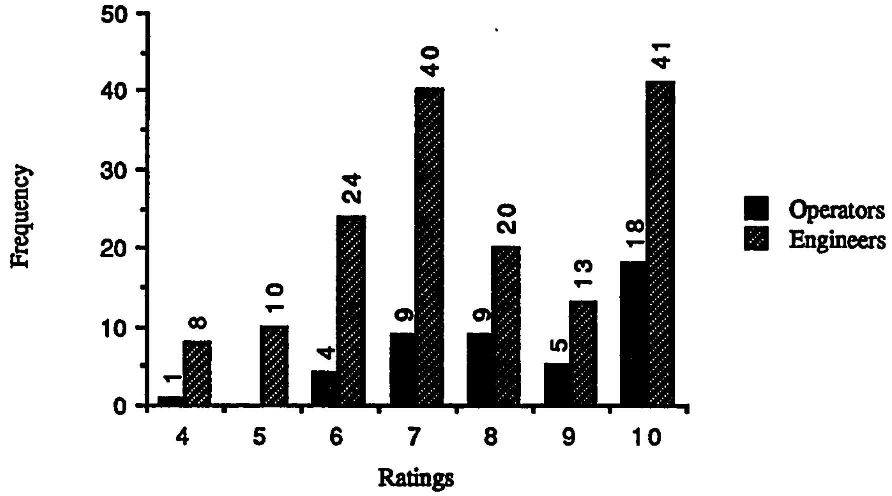


Figure 19. Cell operators and engineers section 3, item 9 response distribution.

Table 43

Cell Operator Section 3, Item 9 Distribution Test

Counts	Scale $\underline{x} < 5.5$	Scale $5.5 < \underline{x} < 6.5$	Scale $6.5 < \underline{x} < 7.5$	Scale $7.5 < \underline{x} < 8.5$	Scale $8.5 < \underline{x} < 9.5$	Scale $9.5 < \underline{x}$	Total
Observ	1	4	9	9	5	18	46
Expect	1.3	3.5	7.7	11.3	11.0	11.2	46

χ^2 (5, $\underline{N}_{oc} = \underline{N}_{ec} = 46$) = 8.23; $\underline{p} > .05$; not significant

Table 44

Engineer Section 3, Item 9 Distribution Test

Count	Scale $\underline{x} < 4.5$	Scale $4.5 < \underline{x} < 5.5$	Scale $5.5 < \underline{x} < 6.5$	Scale $6.5 < \underline{x} < 7.5$	Scale $7.5 < \underline{x} < 8.5$	Scale $8.5 < \underline{x} < 9.5$	Scale $9.5 < \underline{x}$	Total
Obser	8	10	24	40	20	13	41	156
Expect	6.4	11.9	22.8	31.8	33.4	25.9	23.9	156.1

χ^2 (6, $\underline{N}_{oe} = \underline{N}_{ee}$ = 156) = 26.91; $\underline{p} < .001$; significant

Table 45

Cell Operator and Engineer Section 3, Item 9 t Test for Differences between Sample Means

Form	$\underline{N}$	$\underline{M}$	$\underline{SD}_{sample}$
RJDS	46	8.43	1.56
RJRF	156	7.65	1.82

$\underline{SD}_{ce}$ = .30; $\underline{t}_{ce}$ (200) = 2.60; $\underline{p} < .01$; significant

were different from a normal distribution. Results of the $\underline{t}$ test for differences between sample means indicated there was a significant difference ($\underline{p} < .01$) between cell operators' and manufacturing engineers' mean ratings in their view of the cell operator's desire for quick promotion ($\underline{M}_c$ = 8.43; $\underline{M}_e$ = 7.65). The χ^2 "goodness-of-fit" test indicated the distributions of responses between operators and

Table 46

Cell Operators and Engineers Section 3, Item 9 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale $x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observ (Eng)	18	24	40	20	13	41	156
Expect (Oper)	3.4	13.6	30.5	30.5	17.0	61.0	156

χ^2 (5, N_{ec} = 46, N_{oe} = 156) = 84.71; $p < .001$; significant

Table 47

Section 3, Item 9 Analysis of Variance

Group	(SD_{sample}^2)
Cell Operators	2.43
Manufacturing Engineers	3.31

F (45, 155) = 1.36; $p > .05$; not significant

engineers were significantly different ($p < .001$). There was not a significant difference between the variances of the two groups' responses. The engineer modes are 7 (N = 40) and 10 (N = 41). The cell operators' major mode is at 10 (N = 18) and the minor mode is at seven and eight ($N_7 = N_8 = 9$).

Research Question 10

Research Question 10 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for opportunities for personal growth and development in their jobs?" This was transformed from the tenth statement of Section 3 for the RJDS and the RJRF respectively:

_____ 10. Opportunities for personal growth and development in my job.

_____ 10. Opportunities for personal growth and development in his or her job.

Analysis of variance. The analysis of variance permutation of Research Question 10 was "In predicting the desire of the cell operator for opportunities for personal growth and development in his or her job, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 20 shows the responses by category (rating) for each group of respondents. Tables 48, 49, 50, 51, and 52 show respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the t test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 51, the cell operators' responses are used in determining the

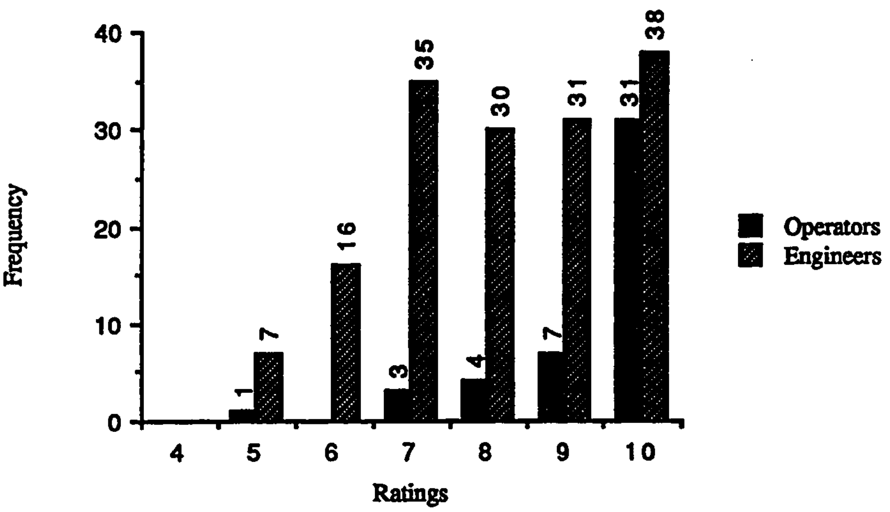


Figure 20. Cell operators and engineers section 3, Item 10 response distribution.

Table 48

Cell Operator Section 3, Item 10 Distribution Test

Counts	Scale Responses $\underline{x} < 7.5$	Scale Responses $7.5 < \underline{x} < 8.5$	Scale Responses $8.5 < \underline{x} < 9.5$	Scale Responses $9.5 < \underline{x}$	Total
Observed	4	4	7	31	46
Expected	2.1	7.9	15.2	20.8	46

χ^2 (3, $\underline{N}_{oc} = \underline{N}_{ec} = 46$) = 13.07; $\underline{p} < .005$; significant

Table 49

Engineer Section 3, Item 10 Distribution Test

Counts	Scale $x < 5.5$	Scale $5.5 < x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observ	7	16	35	30	31	38	157
Expect	6.0	15.5	31.6	41.3	35.0	27.6	157

χ^2 (5, $N_{oe} = N_{ee}$ = 157) = 8.03; $p > .05$; not significant

Table 50

Cell Operator and Engineer Section 3, Item 10 t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	9.37	1.12
RJRF	157	8.12	1.48

SD_{ce} = .24; t_{ce} (201) = 5.21; $p < .01$; significant

expected counts. The actual responses are manufacturing engineers' responses.

Results. The cell operators' responses did not distribute normally and the engineers' responses did distribute normally. Results of the t test for differences between sample means showed a significant difference ($p < .01$) between cell operators' and the engineers' mean ratings of the cell operator's desire for opportunities

Table 51

Cell Operator and Engineer Section 3, Item 10 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale $x < 6.5$	Scale $6.5 < x < 7.5$	Scale $7.5 < x < 8.5$	Scale $8.5 < x < 9.5$	Scale $9.5 < x$	Total
Observe (Eng)	23	35	30	31	38	157
Expect (Oper)	3.4	10.2	13.7	23.9	105.8	157

χ^2 (4, N_{ec} = 46, N_{oe} = 157) = 238.24; $p < .001$; significant

Table 52

Section 3, Item 10 Analysis of Variance

Group	($SD_{sample}{}^2$)
Cell Operators	1.25
Manufacturing Engineers	2.19

F (45, 156) = 1.95; $p < .01$; significant

for personal growth and development on the job (M_c = 9.37; M_e = 8.12). The χ^2 "goodness-of-fit" test indicated the distributions of responses between operators and engineers were significantly different ($p < .001$). The variances of the engineers' and cell operators' responses were significantly different ($p < .01$). The modal response of the cell operators was 10 with 67% of the responses. The modal response for the engineers was also 10 with 24% of the responses.

Research Question 11

Research Question 11 was "Do cell operators and manufacturing engineers differ in their ratings of the cell operators' desire for a sense of worthwhile accomplishment in their work?" This was transformed from the eleventh statement requiring a response of Section 3 for the RJDS and the RJRF respectively:

_____ 11. A sense of worthwhile accomplishment in my work.

_____ 11. A sense of worthwhile accomplishment in his or her work.

Analysis of variance. The analysis of variance permutation of Research Question 11 was "In predicting the desire of the cell operator for a sense of worthwhile accomplishment in his or her work, do the manufacturing engineers' responses vary more than the cell operators' responses?"

The tests. Figure 21 shows the responses by category (rating) for each group of respondents. Tables 53, 54, 55, 56, and 57 show respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the t test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 56, the cell operators' responses were used as a base and as a

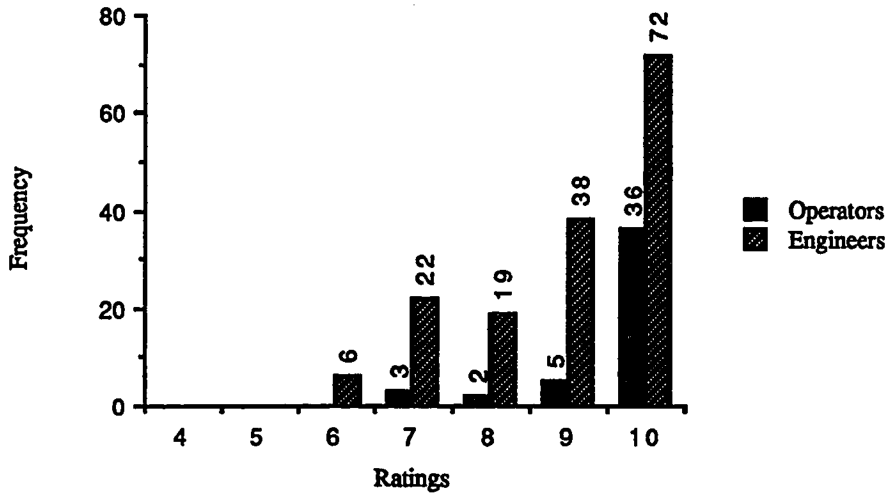


Figure 21. Cell operators and engineers section 3, item 11 response distribution.

Table 53

Cell Operator Section 3, Item 11 Distribution Test

Counts	Scale Responses $x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed	5	5	36	46
Expected	4.4	16.2	25.4	46
χ^2 (2, $N_{oc} = N_{ec} = 46$) = 12.24; $p < .005$; significant				

Table 54

Engineer Section 3, Item 11 Distribution Test

Counts	Scale $\underline{x} < 6.5$	Scale $6.5 < \underline{x} < 7.5$	Scale $7.5 < \underline{x} < 8.5$	Scale $8.5 < \underline{x} < 9.5$	Scale $9.5 < \underline{x}$	Total
Observe	6	22	19	38	72	157
Expect	3.6	15.1	37.7	49.9	50.7	157

χ^2 (4, $\underline{N}_{oe} = \underline{N}_{ee} = 157) = 25.82$; $\underline{p} < .001$; significant

Table 55

Cell Operator and Engineer Section 3, Item 11 t Test for Differences between Sample Means

Form	$\underline{N}$	$\underline{M}$	$\underline{SD}_{sample}$
RJDS	46	9.61	.86
RJRF	157	8.94	1.22

$\underline{SD}_{ce} = .19$; $\underline{t}_{ce}$ (201) = 3.53; $\underline{p} < .01$; significant

template in determining the expected counts. The actual responses were manufacturing engineers' responses.

Results. Both groups' responses were not normally distributed. Results of the $\underline{t}$ test for differences between sample means indicated the mean ratings of cell operators ($\underline{M}_c$ = 9.61) and engineers

Table 56

Cell Operator and Engineer Section 3, Item 11 "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scale Responses $x < 7.5$	Scale Responses $7.5 < x < 8.5$	Scale Responses $8.5 < x < 9.5$	Scale Responses $9.5 < x$	Total
Observed (Engineer)	28	19	38	72	157
Expected (Operator)	10.2	6.8	17.1	122.9	157
χ^2 (3, N_{ec} = 46, N_{oe} = 157) = 99.57; $p < .001$; significant					

Table 57

Section 3, Item 11 Analysis of Variance

Group	($SD_{sample}{}^2$)
Cell Operators	.86
Manufacturing Engineers	1.22
F (45, 156) = 2.01; $p < .01$; significant	

(M_e = 8.94) were significantly different ($p < .01$) concerning the cell operator's desire for a sense of worthwhile accomplishment in his or her work. The χ^2 "goodness-of-fit" test indicated the distributions of responses between operators and engineers were significantly different ($p < .001$). Though both groups' had the same mode of 10, 78% of the operators responded with 10 while 46% of the engineers responded with 10. The variances of the engineers' and cell operators' responses were significantly different ($p < .01$).

Research Question 12

Research Question 12 was "Do cell operators and manufacturing engineers differ in their ratings of cell operators' would like growth need strength (WLGNS)?" The WLGNS equals the average of the responses to Section 3, items 2, 3, 6, 8, 10, and 11 of the RJDS and the RJRF after three is subtracted from each response.

Analysis of variance. The analysis of variance permutation of Research Question 12 was "In predicting the WLGNS, do the manufacturing engineers' responses vary more than the cell operators' responses?

The tests. Figure 22 shows the grouped responses by category (rating) for each group of respondents. Tables 58, 59, 60, 61, and 62 show respectively the testing for cell operator (RJDS) distribution normality, the testing for manufacturing engineer (RJRF) distribution normality, the t test results, the χ^2 "goodness-of-fit" test results, and the analysis of variance for determining if there was a significant difference between cell operators and manufacturing engineers in the distribution of responses provided for each scale category. In Table 61, the cell operators' responses were used as a base and as a template in determining the expected counts. The actual responses were manufacturing engineers' responses.

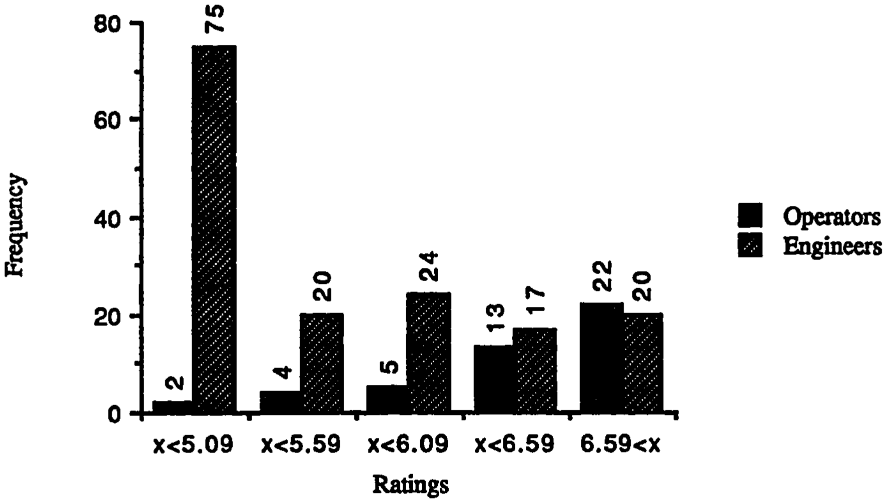


Figure 22. Cell operators and engineers would like growth need strength scores distribution.

Table 58

Cell Operator Would like Growth Need Strength Scores Distribution Test

Counts	Scores $x < 5.09$	Scores $5.09 < x < 5.59$	Scores $5.59 < x < 6.09$	Scores $6.09 < x < 6.59$	Scores $6.59 < x$	Total
Observe	2	4	5	13	22	46
Expect	1.5	3.0	11.0	12.8	17.6	45.9

χ^2 (4, $N_{oc} = N_{ec} = 46$) = 4.87; $p > .05$; not significant

Table 59

Engineer Would Like Growth Need Strength Scores Distribution Test

Count	Scores $x <$ 3.09	Scores 3.09 < x < 3.75	Scores 3.75 < x < 4.42	Scores 4.42 < x < 5.09	Scores 5.09 < x < 5.75	Scores 5.75 < x < 6.42	Scores 6.42 < x	Total
Obser	6	14	25	30	27	32	22	156
Expect	5.9	11.9	23.4	33.1	33.9	25.9	22.0	156.1

χ^2 (6, $N_{oe} = N_{ee}$ = 156) = 3.61; $p > .05$; not significant

Table 60

Cell Operator and Engineer Would Like Growth Need Strength Scores t Test for Differences between Sample Means

Form	N	M	SD_{sample}
RJDS	46	6.38	.71
RJRF	156	5.16	1.18

SD_{ce} = .18; t_{ce} (200) = 6.77; $p < .01$; significant

Results. The scoring of 4 to 10 was transformed to a one-to-seven scale in following the scoring methodology employed by Hackman and Oldham (1980, p. 305). Both the cell operators' distribution and the manufacturing engineers' distribution were not considered different from normal distributions. Results of the t test for differences between sample means indicated the mean ratings of

Table 61

Cell Operator and Engineer Would Like Growth Need Strength Scores "Goodness-of-Fit" Test for Differences in the Distribution of Responses

Counts	Scores $x < 5.09$	Scores $5.09 < x < 5.59$	Scores $5.59 < x < 6.09$	Scores $6.09 < x < 6.59$	Scores $6.59 < x$	Total
Observe (Eng)	75	20	24	17	20	156
Expect (Oper)	6.8	13.6	17.0	44.1	74.6	156.1
χ^2 (4, N_{ec} = 46, N_{oe} = 156) = 749.90; $p < .001$; significant						

Table 62

Section 3, Item 12 Analysis of Variance

Group	($SD_{sample}{}^2$)
Cell Operators	.50
Manufacturing Engineers	1.39
F (45, 155) = 2.78; $p < .01$; significant	

operators and engineers respecting the cell operator's WLGNS, were significantly different ($p < .01$; $M_c = 6.38$; $M_e = 5.16$). The χ^2 "goodness-of-fit" test indicated the distribution of responses between operators and engineers were significantly different ($p < .001$). The engineers' responses varied significantly more than the operators' responses ($p < .01$). The modal score for cell operators, by grouped scores, was 6.84 ($\underline{N}$ = 22; 48%) while the engineers' modal grouped score was 6.09 ($\underline{N}$ = 32; 21%).

Research Question 13

Research Question 13 was "Do cell operators and bench workers differ in their ratings of would like growth need strength?" Nothing was known of the distribution of bench workers' data. Only Hackman and Oldham's (1980) two standard deviation "rule of thumb" test for means being "quite discrepant" was used to test for significant differences

The tests. Table 63 shows the results of the "quite discrepant" two sigma test. In using the "quite discrepant" test, an "average" cell operator group was checked for a fit to the bench worker group, and an "average" bench worker was checked for a fit to the cell operator.

Table 63

Cell Operator/Bench Worker "Quite Discrepant" Test for Differences between Sample Means of Would like Growth Need Strengths

"Average" Person	Person's $\underline{M}$	Group to which person is compared	Group's $\underline{M}$	Group's $\underline{SD}$	$\underline{z}$ score > 2 is significant
Cell Operator	6.38	Bench Worker	5.50	1.40	.63
Bench Worker	5.50	Cell Operator	6.38	.71	-1.24

Results. In comparing the cell operators to bench workers, the would like growth need strengths (WLGNS) were not "quite discrepant." Neither do the group averages and standard deviations indicate similarities (M_c = 6.38; M_b = 5.50; SD_c = .71; SD_b = 1.40). Results are inconclusive.

Research Questions 1 through 12 Results Summary

Table 64 provides a summary in answering the research questions testing for Research Questions 1 through 12. Significance was tested at the .05 level. Where significance was found, the actual confidence level was provided. All t tests were two-tailed tests.

The Cell Operator Core Job Characteristics Profile

The cell operator core job characteristics profile is shown in Figure 23. This was the result of calculations using Sections 1 and 2 responses and Figure 7. Hackman and Oldham claimed that the supervisors' profile of a job and the incumbent employees' profile of a job should be similar in shape. The two sigma limits for determining whether differences were "quite discrepant" were also provided. The order for the core job characteristics in reading from left to right on the x-axis is according to the convention established by Hackman and Oldham for making core job characteristics profiles. Table 65, in part, shows the core job characteristics for the cell operator profile of a job and the incumbent employees' profile of a job should be similar in shape. The two sigma limits for determining whether differences were "quite discrepant" were also provided.

Table 64

Summary of Research Questions 1 through 12.

Research Question #	Cell Operators (RJDS) or Manufact. Engineers (RJRF)	Different from Normal Distribution ? (χ^2)	Difference between Operator and Engineer Sample Means? (t test)	Distribute Differently between Operator and Engineer Groups? (χ^2)
1	Operators	no	no	yes
	Engineers	yes		$p < .005$
2	Operators	yes	yes	yes
	Engineers	yes	$p < .01$	$p < .001$
3	Operators	yes	yes	yes
	Engineers	yes	$p < .01$	$p < .001$
4	Operators	yes	no	yes
	Engineers	yes		$p < .005$
5	Operators	yes	yes	yes
	Engineers	yes	$p < .05$	$p < .001$
6	Operators	yes	yes	yes
	Engineers	no	$p < .01$	$p < .001$
7	Operators	yes	yes	yes
	Engineers	yes	$p < .02$	$p < .001$
8	Operators	yes	yes	yes
	Engineers	no	$p < .01$	$p < .001$
9	Operators	no	yes	yes
	Engineers	yes	$p < .01$	$p < .001$
10	Operators	yes	yes	yes
	Engineers	no	$p < .01$	$p < .001$
11	Operators	yes	yes	yes
	Engineers	yes	$p < .01$	$p < .001$
12	Operators	no	yes	yes
	Engineers	no	$p < .01$	$p < .001$

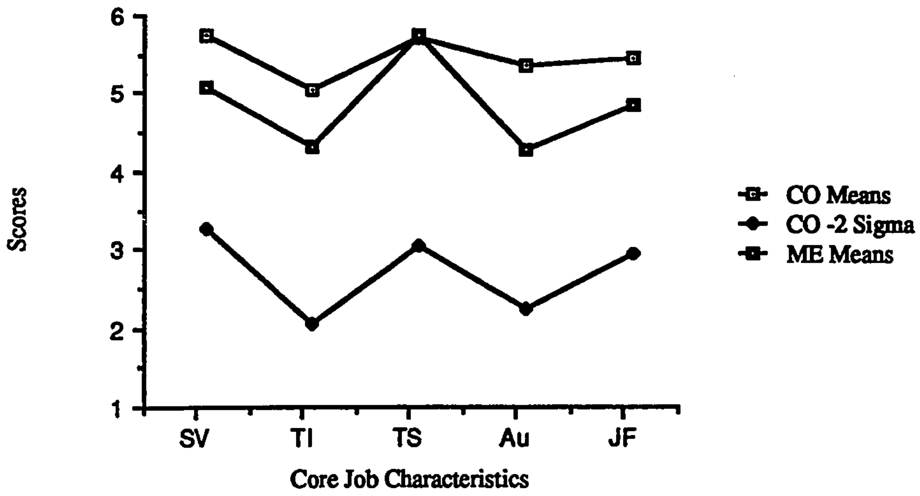


Figure 23. The cell operator's (CO) core job characteristics profile and the manufacturing engineers' (ME) predicted CO profile.

Analyses

The shapes of the line graphs that constituted the core job characteristics profile (as evolved from the respective groups) were similar. According to Hackman and Oldham (1980), this was an indication of a realistic view of the job by the engineers.

Results

Skill variety was the first characteristic graphed. The cell operators' calculated mean rating was 5.63 while the engineers' prediction of the cell operator's rating was 4.95, as calculated. The score was the average of the Section 1, Item 4 response, and Section 2, Items 1 and 5 responses, but Item 5 was reverse scored

Table 65

Core Job Characteristic Profile: Cell Operator and Manufacturing Engineer Views

Core Job Characteristic	Cell Operator M	Cell Operator SD	Cell Operator M predicted by the Manufacturing Engineers
Skill Variety (SV)	5.63	1.25	4.95
Task Identity (TI)	4.91	1.49	4.17
Task Significance (TS)	5.58	1.34	5.62
Autonomy (Au)	5.22	1.56	4.15
Job Feedback (JF)	5.33	1.25	4.74

(8 - respondent's score = used score). Respectively, the items addressed job variety, high-level skills, and job simplicity and repetitiveness.

For task identity, the cell operators' calculated mean rating was 4.91 while the engineers' prediction of the cell operator's rating was 4.17, as calculated. The score was the average of the Section 1, Item 3 response, and Section 2, Items 11 and 3 responses, but Item 3 was reverse scored. The items addressed doing a "whole" piece of work.

For task significance, the cell operators' calculated mean rating was 5.58 while the engineers' prediction of the cell operator's rating was 5.62, as calculated. The score was the average of the Section 1, Item 5 response, and Section 2, Items 8 and 14 responses, but Item 14 was reverse scored.

For autonomy, the cell operators' calculated mean rating was 5.22 while the engineers' prediction of the cell operator's rating was 4.15, as calculated. The score was the average of the Section 1, Item 2 response, and Section 2, Items 13 and 9 responses, but Item 9 was reverse scored.

For feedback from the job, the cell operators' calculated mean rating was 5.33 while the engineers' prediction of the cell operator's rating was 4.74, as calculated. The score was the average of the Section 1, Item 7 response, and Section 2, Items 4 and 12 responses, but Item 12 was reverse scored.

The Motivating Potential Score

The motivating potential score (MPS) served as a rough measure of the inherent characteristics of a job that contributed to work motivation. This meant that a motivated employee probably received reinforcement from a job and continued to perform well if the MPS was high. It was the result of calculations using Sections 1 and 2 responses and Equation 1.

Analyses

A low score meant that a job was not inherently supportive of a motivated worker. Hackman and Oldham (1980) considered an MPS of 128 as average for jobs in the United States (p. 82). Table 66 shows the t test for differences between sample means for the cell operator's MPS as predicted by cell operators and manufacturing engineers.

Table 66

t Test for Differences between Sample Means of Cell Operators' and Engineers' Predictions of Cell Operator MPS

Group	N	M	SD_{sample}
Operators	46	163.83	76.88
Engineers	150	105.18	62.20
t_{ce} (194) = 5.28; $p < .01$; significant			

Results

The cell operator's MPS as determined by the cell operators, was well above the norm (Hackman & Oldham, 1980, p. 105) of all work groups ($MPS_{cell\ operator}$ = 163.83,; $MPS_{all\ groups}$ = 128). The cell operator's MPS, as calculated from engineers' responses was substantially lower than the national norm ($MPS_{cell\ operator\ (engineers'\ data)}$ = 105.18; ΔMPS = 22.82). The cell operators' score and the engineers' score for the cell operator's MPS were significantly different ($p < .01$). The MPS derived from the engineers' responses put the cell operator's MPS between that of the bench worker (MPS = 110) and that of the machine trades (MPS = 136).

"Blue Collar" Would Like Growth Need Strength

Table 67 shows the results analyzed in attempting to get a historical perspective of "blue collar" manufacturing jobs concerning would like growth need strengths. Except for comparing machinists to machine trades where the same group was effectively considered,

Table 67

Some Comparisons of WLGNS Measures Among Different Groups and Across Time

Measure of Interest	1980 Bench Workers	1980 Machine Trades	1990 Machinists	Cell Operators
M	5.5	5.5	5.23	6.38
SD	1.40	1.20	1.26	.71

only a priori testing was available as the values provided were not measures of the same group's would like growth need strengths.

Analyses

Table 68 shows the χ^2 "goodness-of-fit" test used in determining the distribution of the machinists' WLGNS. The *t* test used for finding differences between machine trades in 1980 and machinists in 1990 is shown in Table 69.

Results

The machinists' WLGNS (1980) was effectively the same as the machine trades' WLGNS ($M_{\text{machinists}}$ = 5.23; $M_{\text{machine trades}}$ = 5.5; $SD_{\text{machinists}}$ = 1.26; $SD_{\text{machine trades}}$ = 1.20). The bench workers' standard deviation (SD = 1.40; M = 5.50) indicated the largest group variance. The engineers' calculated "prediction" of the cell operator's WLGNS (M_e = 5.16, SD_e = 1.18) was comparable to the WLGNS of the bench workers, machine trades, and machinists in both mean and standard deviation.

Table 68

Machinists "Goodness-of-Fit" Test for Determining Distribution Normality of Would Like Growth Need Strength Scores

Counts	Scores $x < 3.59$	Scores $3.59 < x < 4.75$	Scores $4.75 < x < 5.92$	Scores $5.92 < x$	Total
Observed	2	6	7	7	22
Expected	2.0	5.7	8.0	6.3	22

χ^2 (3, N = 22) = 0.23; $p > .05$; not significant

Table 69

t test for Determining Change in Machine Trades'/Machinists' Would Like Growth Need Strengths over Time

Machine Trades 1980 M	Machinists 1990 M	Machinists 1990 SD	Machinists N
5.50	5.23	1.26	22

t (21) = 1.01; $p > .05$; not significant

Rankings of Cell Operator Motivating Characteristics

Examining the results of this study provide direction toward understanding cell operator job design and toward implementing the results as part of the whole that is job design. Table 70 shows the overall ranking of the Section 3 choices.

Table 70

Rankings of Cell Operator Motivating Characteristics by Cell Operators (CO) and Manufacturing Engineers (ME)

Motivating Characteristic	CO Rank (M)	ME Rank (M)
7. high salary and good fringe benefits.	1 (9.70)	2 (9.26)
6. Opportunities to learn new things from the work.	2 (9.63)	5 (8.13)
11. A sense of worthwhile accomplishment in the work.	3 (9.61)	4 (8.94)
8. Opportunities to be creative and imaginative in the work.	4 (9.48)	10 (7.80)
4. Great job security	5.5 (9.37)	1 (9.31)
10. Opportunities for personal growth and development in the work.	5.5 (9.37)	6 (8.12)
3. Chances to exercise independent thought and action in the job.	7 (9.13)	8 (7.91)
2. Stimulating and challenging work.	8 (9.04)	7 (8.09)
1. High respect and fair treatment from the supervisor.	9 (8.85)	3 (9.18)
5. Very friendly coworkers.	10 (8.46)	9 (7.83)
9. Quick promotions.	11 (8.43)	11 (7.65)

Analyses

It was presumed that cell operators' and engineers' means could serve in ranking the choices. The cell operators' rankings determined the order of presentation of the motivating characteristics.

Results

Of the cell operators' first four choices, three reflected higher order needs. Only one choice, the first choice, pay, was a basic need. The engineers ranked pay second. The engineers ranked "great job security" first which was ranked fifth (in a tie with "opportunities for personal growth and development in the work") by the operators. Only the engineers' fourth choice, ("a sense of worthwhile accomplishment in the work") of their first four choices was a higher order need. The operators ranked the same characteristic third. The operators' second and fourth choices respectively were "opportunities to learn new things from the work" and "opportunities to be creative and imaginative in the work." The engineers' third choice, "high respect and fair treatment from the supervisor," was a basic need in emphasizing fair treatment.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Productivity was the concern that initiated this study. A belief in the power of people using technology rather than technology replacing people was the premise of maintaining and increasing productivity. One occupation, the cell operator in computer integrated manufacturing (CIM), was examined. Though such a person appears to be in a critical role in answering the productivity question, examining other occupations in manufacturing should also be considered. Indeed, indirectly the manufacturing engineer was also examined in this study. It can be seen that the examination of that role also holds many answers to the productivity question. It is advised that productivity be viewed holistically such that specific examinations are always respected in the context of the whole manufacturing environment.

Summary

The first purpose of this study was to determine the factors that motivate cell operators. Regarding job design, a second purpose of this study was to strongly encourage manufacturing engineers to become aware of the importance of knowing what motivates the cell operators. It was necessary to know and show what motivated cell operators so the engineer could facilitate the operator's role and tasks in the CIM environment. Manufacturing engineers were important because they had the primary role of cell operator job design. As the engineers and cell operators were seen together as a positive combination in work design, it was felt that it was important for the engineers to know what motivated the operators in assuring good cell operator job design. The engineers ability to predict the strength of the factors that motivated cell operators was the focus of the investigation. The question took the form of 12 individual research questions. A 13th question compared the would like growth need strength (WLGNS) of cell operators and bench workers.

There were three problems examined in this study. The first problem was determining the elements of job enrichment for the cell operator and their level of importance to the operator. Determining the engineers' predictions of the importance of the elements of job enrichment to the cell operator was the second problem of the study. The third problem of the study was determining if significant differences existed between the opinions of the operators and engineers respecting the motivating or job enrichment factors of the cell operator.

The first subsection of the literature review presented an historical perspective of work design and work attitudes in orienting the reader toward the direction of the study on the spectrum of Taylorism and Scientific Management on one extreme and considerations of human factors on the other end of the spectrum. The second subsection examined automation and reciprocal effects concerning people. The third subsection detailed job design respecting contemporary views and the work motivation theories.

The fourth subsection examined the related studies previously conducted. Six of the related studies involved supervisors predicting responses of their subordinates. Common to most studies was the observation and/or opinion that supervisors referenced their value systems in predicting employee responses. The fifth subsection dealt with the methodology rationale in examining closely-related studies. The studies involved foremen predicting the responses of their subordinates.

The sixth subsection detailed the Job Diagnostic Survey (JDS) and the Job Rating Form (JRF). Revisions of these instruments were used to collect data from cell operators and manufacturing engineers for this study.

The methodology established for answering the research questions was to compare responses of cell operators and manufacturing engineers between similar items of, respectively, a revised JDS (RJDS), and a revised JRF (RJRF). The statistical tests used were the t test for differences between sample means, the χ^2 "goodness-of-fit" test in determining differences in the distribution of group responses, Hackman and Oldham's (1980) "quite discrepant" two sigma difference test, the simple t test (for comparing machine trades' and machinists' responses), and analyses of variance. The questionnaires were mailed to samples of both groups simultaneously.

Results were found by tabulating seven point Likert scale responses for each item. Means for each item were calculated for cell operators and manufacturing engineers. The core job characteristics scores and the motivating potential score (MPS) were also calculated. The core job characteristics were line graphed as the core job characteristics profile.

Responses to 11 items were considered individually in answering the first 11 research questions of the total of 13 research questions. Six of the items also constituted the score for WLGNS which involved answering the question "Do cell operators and manufacturing engineers differ in their ratings of the cell operator's would like growth need strength (WLGNS)?" Another question "Do cell operators and bench workers differ in their ratings of WLGNS?," was answered using the Hackman and Oldham (1980) "quite discrepant" two sigma test.

Though most of the samples were not normally distributed, the *t* test analyses were still considered acceptable as the sample sizes (N) exceeded 10 (N_{ec} = 46, N_{oe} = 157) which permits the use of the *t* test results (Herzberg, 1983). That is, the *t* test is sufficiently robust in its applications provided sample sizes are large ($N > 10$). Accordingly, the *t* test for differences between sample means for responses of operators and engineers to all items that measured factors that motivate people at work, were significantly different except for (using the wording of the research questions) "high respect and fair treatment from his or her supervisor" and "great job security."

For seven items response significance was at the .01 level. Those items were (using the wording of the research questions) "Stimulating and challenging work," "chances to exercise independent thought and action in his or her job," "opportunities to learn new things from his or her work," "opportunities to be creative and imaginative in his or her work," quick promotion," "opportunities for personal growth and development in his or her job," and "a sense of worthwhile accomplishment in his or her work." For one item, "very friendly coworkers," response significance was at the .05 level. For the remaining item, "high salary and good fringe benefits," response significance was at the .02 level.

In answering Research Question 12, the ratings of the cell operator's WLGNS, as calculated from cell operators' and manufacturing engineers' responses, were significantly different using the t test for differences between sample means ($p < .01$). In answering Research Question 13, it was found that the WLGNSs of cell operators and bench workers were not "quite discrepant."

The two core job characteristics profiles for the cell operator occupation, as plotted, were the results of using responses to items of the instruments that were elements of job enrichment. It appears that the cell operators and the manufacturing engineers see job enrichment comparably. That is, the ratings of need of the elements skill variety, task identity, task significance, autonomy, and feedback from the job itself are relatively similar and not "quite discrepant."

The MPSs for the cell operator job, as calculated from cell operator responses and manufacturing engineers, were significantly different. The WLGNS for machinists (1990) did not appear to change since 1980 (machine trades).

Conclusions

While the cell operators' four top-rated choices reflect higher order needs, the engineers believe the cell operators' primarily motivated by lower order needs. This is very consistent with the results of previous studies comparing the responses of supervisors and their subordinates.

'The engineers saw job enrichment factors as part of the cell operator's job, yet they rate basic needs higher for the cell operator than higher order needs. The engineers are aware that elements of would like growth need strength are desired by the operators though they do not appreciate the "intensity" of the desire that shows in the cell operators' responses (high scores with "tight" variances). Yet the engineers' calculated prediction of the MPS is significantly lower than the operators' calculated choice. The argument that best fits with these apparently contradictory results is that the engineers see the enrichment factors as natural elements of the operator's job without reflecting upon specifically incorporating these factors. That is, enrichment is not seen as something added to the job, but as something inherent in the job. There may be the passive attitude that "some jobs have it and some jobs don't." Thus, there is no active consideration of enrichment in design. The argument would also explain the engineers' low MPS rating while having an awareness of the operators' desires for higher order needs as shown in Section 3 responses. That is, the engineer can sympathize with the operator's desire for higher order needs, but the engineer does not see himself or herself in the role of facilitator of those needs. The engineer just does not appreciate the importance of job design in maintaining motivation. Because of the engineers' perception of the cell operators' preferences for basic needs, it can probably be said that the engineers feel the operators are on the job to "make a living." If the operator has a good job then that's "great" particularly if management has seen fit to satisfy basic needs. The picture constructed from this research is one of everyone's awareness for the desire for higher order needs, but the engineers do not see their role in facilitating the <u>process</u> of satisfying higher order needs. Technical considerations are probably the main, if not the only, consideration in job design.

In conclusion, the engineers are asked to reflect upon the lack of an experience base in CIM in general, and upon that lack of experience in the cell operator role specifically. The question to be answered is: Can there be enough technical considerations in cell operator job design to negate the variety, duration, and magnitude of unexpected events or should job motivation be an important active consideration such that operator motivation is activated and maintained in facilitating the acceptance of the challenges presented by the <u>inevitable</u> unexpected events?

Recommendations

These recommendations are made in two parts. This approach of making general methodological recommendations separate from recommendations for conducting different studies is done only to facilitate clarity. The specific recommendations follow.

Methodological Considerations

1. Conduct similar national studies using different mailing list resources. A profile of representative groups should result. Study validity should be strengthened.

2. Draw larger samples from larger populations. Variance differences due to instrument problems or group cohesiveness need clarification.

3. On the survey instruments, include critical definitions. In the Likert scales, such terms as "moderate" and "extremely" for Section 3 responses, need clarification.

4. Use a Likert scale designed specifically for surveying operators and engineers. Perhaps, terms for scale point descriptions can be versed in an agreed-upon terminology.

5. For third class mailings, specify response deadlines no earlier than three weeks after the date the survey forms are deposited with the Postal Service.

6. The use of first class mailing is preferred. Otherwise, too much of the survey control is put in the hands of individual mail carriers.

7. Send the follow-up letter about five days after the original mailing. Sending out follow-up letters earlier than five days creates the possibility of the follow-up "passing" the original mailing in the mail for national mailings. Sending out follow-ups later than five days creates the possibility of extinguishing the intent to respond.

For Further Study

1. Replicate the study incorporating the methodological recommendations. Replication should verify or identify true group differences and/or true methodological differences.

2. Determine a universal definition of the cell operator. Without the definition provided in this study, the term cell operator could have meant very different things to different people. A standard definition would reduce cell operator study variances.

3. Determine the adequacy of the CIM operator profile resulting from this study. Implementation of study results is recommended in determining the adequacy of the profile.

4. Develop CIM operator profiles for successful CIM users' operators. Upon implementation of study results, users should be impressed with the need to feed back to the researchers the differences they have found or that independent observers have found.

5. Investigate the extent specialized job enrichment and motivation knowledge is incorporated by practicing work designers. Though engineers may agree on the results of job enrichment and

motivation research, there is no indication of a general implementation of results.

6. Examine the interaction of industrial engineers and the job enrichment and motivation specialists. The need for the two groups to work together is envisioned.

7. Investigate the apparent dichotomy of engineers' responses concerning practical job design. That is, why do engineers implement one practical methodology while professing another theoretical methodology?

8. Expand studying in detail what motivates cell operators and expand upon understanding what motivates cell operators. In originally positing the need for this study, it was indicated the cell operator was critical to productivity.

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APPENDIX A

RESEARCH ACTIVITY

1. Proposal reviewed by committee ....April, 1990
2. Proposal approved by committee members ....May, 1990
3. Chapter One completed, data collection started ....June, 1990
4. Chapters Two and Three completed,
   data collection completed ....July, 1990
5. Chapters Four and Five completed,
   dissertation submitted to advisor ....August, 1990
6. Dissertation revised and submitted to advisor ....October, 1990
7. Dissertation revised and submitted to advisor ....November, 1990
8. Dissertation defended ....December, 1990
9. Dissertation changes submitted ....January, 1991

Figure A-1. Research activity time costs.

APPENDIX B

PROJECT BUDGET

Printing and supplies,	
(350 machinists, 675 manufacturing engineers)	$403.94
Gardner Publications mailing lists,	
(332 machinists, 668 manufacturing engineers)	305.50
Return postage (1000 pieces)	266.80
First mailing postage	74.68
Second mailing postage	74.34
TOTAL COSTS	$1125.26

Figure B-1. Actual project fiscal costs.

APPENDIX C

A CORE JOB CHARACTERISTICS MODEL

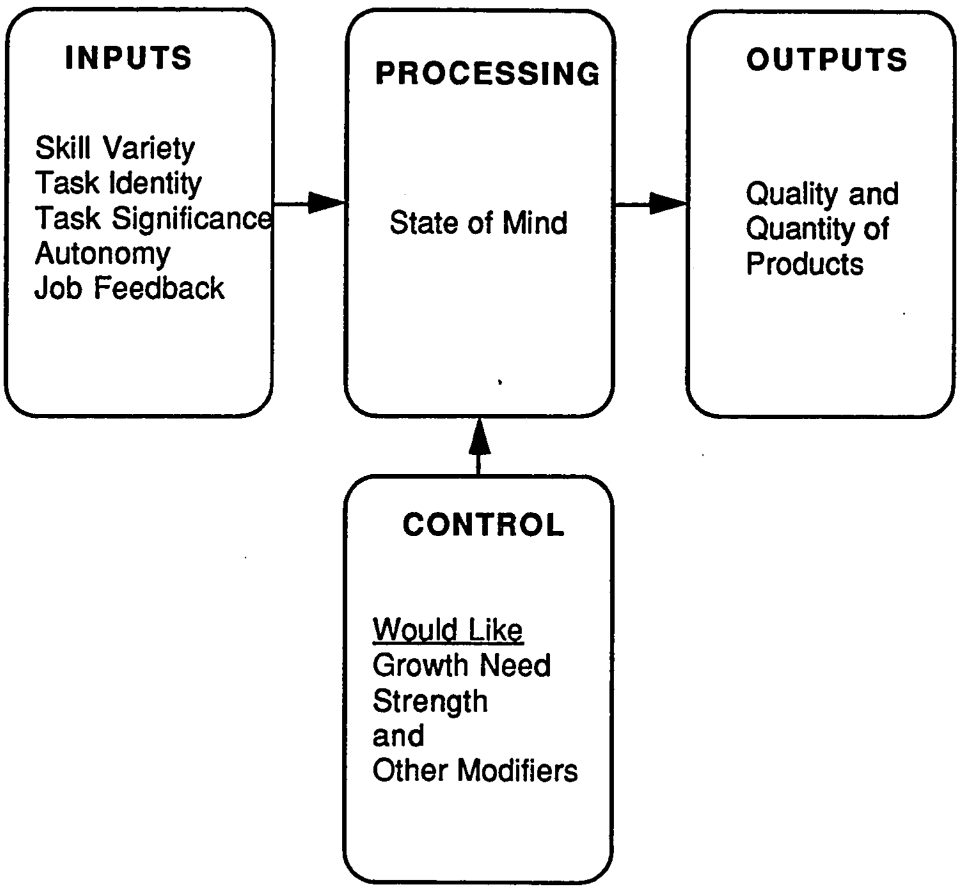

Figure C-1. A technical system core job characteristics model.

APPENDIX D

COMPARISONS OF RANKINGS

Table D-1

A Comparison of Rankings of Four Factors Common to Five Studies

Factor	LRI 1946		Hoh 1980		Kovach 1980		Kovach 1986		CIM 1990	
	E	S	E	S	E	S	E	S	O	M
High salary and good fringe benefits	3	1	1	1	4	1	4	1	1	2
Sense of worthwhile accomplishment in the work	1	4	3	2	2	4	2	4	2	3
Great job security	2	2	2	3	3	2	3	2	3	1
Stimulating and challenging work	4	3	4	4	1	3	1	3	4	4

Note. CIM referred to the study of cell operators which also involved manufacturing engineers. The factors for comparison in all of the studies have utilized wording from the CIM study. Rankings were considered as though the factors were the only factors to be ranked.

E = employees M = manufacturing engineers

O = operators S = supervisors

Table D-2

A Comparison of Rankings of Six Factors Common to Four Studies

Factor	LRI 1946		Kovach 1980		Kovach 1986		CIM 1990	
	E	S	E	S	E	S	O	M
High salary and good fringe benefits	3	1	4	1	4	1	1	2
Sense of worthwhile accomplishment in my work	1	6	2	6	2	6	2	4
Great job security	2	2	3	2	3	2	3	1
Stimulating and challenging work	4	4	1	4	1	4	4	5
High respect and fair treatment from the supervisor	6	5	6	5	6	5	5	3
Quick promotions	5	3	5	3	5	3	6	6

Note. CIM referred to the study of cell operators which also involved manufacturing engineers. The factors for comparison in all of the studies have utilized wording from the CIM study. Rankings were considered as though the factors were the only factors to be ranked.

E = employees M = manufacturing engineers

O = operators S = supervisors

Table D-3

A Comparison of Rankings of Eight Factors Common to Two Studies

Factor	Hoh 1980		CIM 1990	
	E	S	O	M
-High salary and good fringe benefits	1	1	1	2
-Opportunities to learn new things from my work	2	8	2	4
-A sense of worthwhile accomplishment in my work	5	3	3	3
-Opportunities to be creative and imaginative in my work	7	5	4	8
-Great job security	4	6	5	1
-Chances to exercise independent thought and action in my job	8	4	6	6
-Stimulating and challenging work	6	7	7	5
-Very friendly coworkers	3	2	8	7

Note. CIM referred to the study of cell operators which also involved manufacturing engineers. The factors for comparison in all of the studies have utilized wording from the CIM study. Rankings were considered as though the factors were the only factors to be ranked.

E = employees M = manufacturing engineers

O = operators S = supervisors

APPENDIX E

HACKMAN'S RESPONSE

Subject: Use of the terms Job Diagnostic Survey and Job Rating Form for instruments known to not be the JDS or JRF

Dear Dr. Hackman:

Thank you for the direction in finding the means and standard deviations for the 'would like' GNSs based on various demographic criteria. They are very useful and probably necessary in treating my study results. I could not help noticing that your correspondence arrived on the day (7/2/90) of peak returns from my surveys. I assumed then, that your note followed a review of my instruments. I expected a commentary, but did not receive it on one point.

As I am getting unexpected positive indications of the value of my study, and I already have a request for publication of results from one publisher, it appears the dissertation will not sit on the shelf. Thus, that point, using the term 'Job Diagnostic Survey' for what is really not the complete JDS (*and* it has been modified),would cause problems. I have the same complimentary concern respecting the use of the term 'Job Rating Form'. My concerns are of ethics. I do not want to remove the JDS descriptor as the instrument is in essence your instrument. However, I do not want to call it something else and mislead the readership. If I call it JDS Form Z then I run the risk of confusing it with a Form Z that may exist and/or it implies that the instrument has the approval of yourself, Dr. Oldham, Dr. Stepina, and/or Dr. Lawler. I know I will not and should not get your approval for such a new and untested instrument.

I would appreciate some suggestions on what, henceforth, to call this instrument. If I accept a suggestion, please let me know how you wish

Mr. [illegible] —
why don't you just
say "a revised" in the
version of the JDS and list 54
method section, in the [illegible]
Then in "The revised JDS" [illegible] in getting
[illegible] results.

Figure E-1. Hackman's correspondence suggesting the use of the JDS as a revised JDS. Reduced 35%.

APPENDIX F

DATA COLLECTION MATERIALS

Please put a check in ALL spaces that best fit your opinion.

____ Yes, I operate or run metals machining equipment.

____ Yes, I use a computer (PLCs, microcomputers, or etc.) on my job.

____ I use a computer in helping with the processing of machined parts.

____ I use a computer in determining which parts will be machined next.

My job title or description is ______________________________

and I have worked in this job classification for ____ year(s) and ____ month(s).

JOB DIAGNOSTIC SURVEY

This questionnaire was developed as part of a Yale University study of jobs and how people react to them. The questionnaire helps to determine how jobs can be better designed, by obtaining information about how people react to different kinds of jobs.

On the following pages you will find several different kinds of questions about your job. Specific instructions are given at the start of each section. Please read them carefully. It should take no more than 15 minutes to complete the entire questionnaire. Please move through it quickly.

The questions are designed to obtain *your* perceptions of your job and *your* reactions to it. There are no trick questions. Your individual answers will be kept completely confidential. Please answer each item as honestly and frankly as possible. Thank you for your cooperation.

SECTION ONE

This part of the questionnaire asks you to describe your job, as *objectively* as you can. Please do *not* use this part of the questionnaire to show how much you like or dislike your job. Instead, try to make your descriptions as accurate and as objective as you possibly can.

A sample question is given below.

A. To what extent does your job require you to work with mechanical equipment?

1-------2-------3-------4-------5-------6-------7

1	4	7
Very little; the job requires almost no contact with mechanical equipment of any kind.	Moderately	Very much; the job requires almost constant work with mechanical equipment.

You are to *circle* the number which is the most accurate description of your job. If, for example, your job requires you to work with mechanical equipment a good deal of the time -but also requires some paperwork- you might circle the number six, as was done in the example above.

Please begin responding here:

1. To what extent does your job require you to work *closely with other people* (either "clients," or people in related jobs in your own organization)?

1-------2-------3-------4-------5-------6-------7

1	4	7
Very little; dealing with other people is not at all necessary in doing the job.	Moderately; some dealing with others is necessary.	Very much; dealing with other people is an absolutely essential and crucial part of doing the job.

Figure F-1. Page 1 of the RJDS instrument (reduced 35%).

2. How much *autonomy* is there in your job? That is, to what extent does your job permit you to decide *on your own* how to go about doing the work?

1-------2-------3-------4-------5-------6-------7

Very little; the job gives me almost no personal "say" about how and when the work is done.	Moderate autonomy; many things are standardized and not under my control, but I can make some decisions about the work.	Very much; the job gives me almost complete responsibility for deciding how and when the work is done.

3. To what extent does your job involve doing a *"whole" and identifiable piece of work?* That is, is the job a complete piece of work that has an obvious beginning and end? Or is it only a small *part* of the overall piece of work, which is finished by other people or by automatic machines?

1-------2-------3-------4-------5-------6-------7

My job is only a tiny part of the overall piece of work; the results of my activities cannot be seen in the final product or service.	My job is a moderate-sized "chunk" of the overall piece of work; my own contribution can be seen in the final outcome.	My job involves doing the whole piece of work, from start to finish; the results of my activities are easily seen in the final product or service.

4. How much *variety* is there in your job? That is, to what extent does the job require you to do many different things at work, using a variety of your skills and talents?

1-------2-------3-------4-------5-------6-------7

Very little; the job requires me to do the same routine things over and over again.	Moderate variety.	Very much; the job requires me to do many different things, using a number of different skills and talents.

5. In general, how *significant or important* is your job? That is, are the results of your work likely to significantly affect the lives or well-being of other people?

1-------2-------3-------4-------5-------6-------7

Not very significant; the outcomes of my work are *not* likely to have important effects on other people.	Moderately significant.	Highly significant; the outcomes of my work can affect other people in very important ways.

6. To what extent do *managers or co-workers* let you know how well you are doing on your job?

1-------2-------3-------4-------5-------6-------7

Very little; people almost never let me know how well I am doing.	Moderately sometimes people may give me "feedback"; other times they may not.	Very much; managers or co-workers provide me with almost constant "feedback" about how well I am doing.

Figure F-2. Page 2 of the RJDS instrument (reduced 35%).

7. To what extent does *doing the job itself* provide you with information about your work performance? That is, does the actual work *itself* provide clues about how well you are doing -aside from any "feedback" co-workers or supervisors may provide?

1-------2-------3-------4-------5-------6-------7

1	4	7
Very little; the job itself is set up so I could work forever without finding out how well I am doing.	Moderately; sometimes doing the job provides "feedback" to me; sometimes it does not.	Very much; the job is set up so that I get almost constant "feedback" as I work about how well I am doing.

SECTION TWO

Listed below are a number of statements which could be used to describe a job. You are to indicate whether each statement is an *accurate* or an *inaccurate* description of *your job*. Once again, please try to be as objective as you can in deciding how accurately each statement describes your job regardless of whether you like or dislike your job.

Write a number in the blank beside each statement, based on the following scale:

How accurate is the statement in describing your job?						
1 Very Inaccurate	2 Mostly Inaccurate	3 Slightly Inaccurate	4 Uncertain	5 Slightly Accurate	6 Mostly Accurate	7 Very Accurate

____ 1. The job requires me to use a number of complex or high-level skills.

____ 2. The job requires a lot of cooperative work with other people.

____ 3. The job is arranged so that I do *not* have the chance to do an entire piece of work from beginning to end.

____ 4. Just doing the work required by the job provides many chances for me to figure out how well I am doing.

____ 5. The job is quite simple and repetitive.

____ 6. The job can be done adequately by a person working alone -without talking or checking with other people.

____ 7. The supervisors and co-workers on this job almost *never* give me any "feedback" about how well I am doing in my work.

____ 8. This job is one where a lot of other people can be affected by how well the work gets done.

____ 9. The job denies me any chance to use my personal initiative or judgment in carrying out the work.

____10. Supervisors often let me know how well they think I am performing the job.

____11. The job provides me the chance to completely finish the pieces of work I begin.

____12. The job itself provides very few clues about whether or not I am performing well.

(Continued on the next page)

Figure F-3. Page 3 of the RJDS instrument (reduced 35%).

How accurate is the statement in describing your job?						
1 Very Inaccurate	2 Mostly Inaccurate	3 Slightly Inaccurate	4 Uncertain	5 Slightly Accurate	6 Mostly Accurate	7 Very Accurate

_____13. The job gives me considerable opportunity for independence and freedom in how I do the work.

_____14. The job is *not* very significant or important in the broader scheme of things.

SECTION THREE

Listed below are a number of characteristics which could be present on any job. People differ about how much they would like to have each one present in their own jobs. We are interested in learning *how much you personally would like* to have each one present in your job.

Using the scale below, please indicate the *degree* to which you *would like* to have each characteristic present in your job.

NOTE: The numbers on this scale are different from those used in previous scales.

4	5	6	7	8	9	10
Would like having this only a moderate amount (or less)			Would like having this very much			Would like having this *extremely* much

_____ 1. High respect and fair treatment from my supervisor.

_____ 2. Stimulating and challenging work.

_____ 3. Chances to exercise independent thought and action in my job.

_____ 4. Great job security.

_____ 5. Very friendly co-workers.

_____ 6. Opportunities to learn new things from my work.

_____ 7. High salary and good fringe benefits.

_____ 8. Opportunities to be creative and imaginative in my work.

_____ 9. Quick promotions.

_____10. Opportunities for personal growth and development in my job.

_____11. A sense of worthwhile accomplishment in my work.

Figure F-4. Page 4 of the RJDS instrument (reduced 35%).

Please put a check in the one space that best fits your opinion.

____ Yes, I am definitely a manufacturing engineer.

____ I am *not* a manufacturing engineer, but I have responded anyway.

My job title or description is ____________________

and I have worked in this job classification for ____ year(s) and ____ month(s).

JOB RATING FORM

This questionnaire was developed as part of a Yale University study of jobs and how people react to them. The questionnaire helps to determine how jobs can be better designed, by obtaining information about how people react to different kinds of jobs.

You are asked to rate the characteristics of the following job:

Cell Operator (CNC operator, FMS operator, or etc.) as described in the cover letter.

Please keep in mind the questions refer to the job listed above, and *not* to your own job.

On the following pages, you will find several different kinds of questions about the job listed above. Specific instructions are given at the start of each section. Please read them carefully. It should take no more than 15 minutes to complete the entire questionnaire. Please move through it quickly.

SECTION ONE

This part of the questionnaire asks you to describe the job listed above as *objectively* as you can. Try to make your description as accurate and as objective as you possibly can.

A sample question is given below.

A. To what extent does the job require a person to work with mechanical equipment?

1-------2-------3-------4-------5-------6-------7

1	4	7
Very little; the job requires almost no contact with mechanical equipment of any kind.	Moderately	Very much; the job requires almost constant work with mechanical equipment.

You are to *circle* the number which is the most accurate description of the job you are rating. If, for example, the job requires a person to work with mechanical equipment a good deal of the time -but also requires some paperwork- you might circle the number six, as was done in the example above.

Please begin responding here:

1. To what extent does the job require a person to *work closely with other people* (either "clients," or people in related jobs in the organization)?

1-------2-------3-------4-------5-------6-------7

1	4	7
Very little; dealing with other people is not at all necessary in doing the job.	Moderately; some dealing with others is necessary.	Very much; dealing with other people is an absolutely essential and crucial part of doing the job.

Figure F-5. Page 1 of the RJRF instrument (reduced 35%).

2. How much *autonomy* is there in the job? That is, to what extent does the job permit a person to decide *on his or her own* how to go about doing the work?

1-------2-------3-------4-------5-------6-------7

Very little; the job gives a person almost no personal "say" about how and when the work is done.	Moderate autonomy; many things are standardized and not under the control of the person, but he or she can make some decisions about the work.	Very much; the job gives the person almost complete responsibility for deciding how and when the work is done.

3. To what extent does the job involve doing a *"whole" and identifiable piece of work*? That is, is the job a complete piece of work that has an obvious beginning and end? Or is it only a small *part* of the overall piece of work, which is finished by other people or by automatic machines?

1-------2-------3-------4-------5-------6-------7

The job is only a tiny part of the overall piece of work; the results of the person's activities cannot be seen in the final product or service.	The job is a moderate-sized "chunk" of the overall piece of work; the person's own contribution can be seen in the final outcome.	The job involves doing the whole piece of work, from start to finish; the results of the person's activities are easily seen in the final product or service.

4. How much *variety* is there in the job? That is, to what extent does the job require a person to do many different things at work, using a variety of his or her skills and talents?

1-------2-------3-------4-------5-------6-------7

Very little; the job requires the person to do the same routine things over and over again.	Moderate variety.	Very much; the job requires the person to do many different things, using a number of different skills and talents.

5. In general, how *significant or important* is the job? That is, are the results of the person's work likely to significantly affect the lives or well-being of other people?

1-------2-------3-------4-------5-------6-------7

Not at all significant; the outcomes of the work are *not* likely to affect anyone in any important way.	Moderately significant.	Highly significant; the outcomes of the work can affect other people in very important ways.

6. To what extent do *managers or co-workers* let the person know how well he or she is doing on the job?

1-------2-------3-------4-------5-------6-------7

Very little; people almost never let the person know how well he or she is doing.	Moderately; sometimes people may give the person "feedback"; other times they may not.	Very much; managers or co-workers provide the person with almost constant "feedback" about how well he or she is doing.

Figure F-6. Page 2 of the RJRF instrument (reduced 35%).

7. To what extent does *doing the job itself* provide the person with information about his or her work performance? That is, does the actual *work itself* provide clues about how well the person is doing -aside from any "feedback" co-workers or supervisors may provide?

1-------2-------3-------4-------5-------6-------7

1	4	7
Very little; the job itself is set up so a person could work forever without finding out how well he or she is doing.	Moderately; sometimes doing the job provides "feedback" to the person; sometimes it does not.	Very much; the job is set up so that a person gets almost constant "feedback" as he or she works about how well he or she is doing.

SECTION TWO

Listed below are a number of statements which could be used to describe a job. You are to indicate whether each statement is an *accurate* or an *inaccurate* description of the job you are rating. Once again, please try to be as *objective* as you can in deciding how accurately each statement describes the job -regardless of your own *feelings* about that job.

Write a number in the blank beside each statement, based on the following scale:

How accurate is the statement in describing the job you are rating?						
1 Very Inaccurate	2 Mostly Inaccurate	3 Slightly Inaccurate	4 Uncertain	5 Slightly Accurate	6 Mostly Accurate	7 Very Accurate

____ 1. The job requires a person to use a number of complex or sophisticated skills.

____ 2. The job requires a lot of cooperative work with other people.

____ 3. The job is arranged so that a person does *not* have the chance to do an entire piece of work from beginning to end.

____ 4. Just doing the work required by the job provides many chances for a person to figure out how well he or she is doing.

____ 5. The job is quite simple and repetitive.

____ 6. The job can be done adequately by a person working alone -without talking or checking with other people.

____ 7. The supervisors and co-workers on this job almost *never* give a person any "feedback" about how well he or she is doing the work.

____ 8. This job is one where a lot of other people can be affected by how well the work gets done.

____ 9. The job denies a person any chance to use his or her personal initiative or discretion in carrying out the work.

____10. Supervisors often let the person know how well they think he or she is performing the job.

____11. The job provides a person with the chance to finish completely any work he or she starts.

(Continued on the next page)

Figure F-7. Page 3 of the RJRF instrument (reduced 35%).

How accurate is the statement in describing the job you are rating?						
1 Very Inaccurate	2 Mostly Inaccurate	3 Slightly Inaccurate	4 Uncertain	5 Slightly Accurate	6 Mostly Accurate	7 Very Accurate

____12. The job itself provides very few clues about whether or not the person is performing well.

____13. The job gives a person considerable opportunity for independence and freedom in how he or she does the work.

____14. The job itself is *not* very significant or important in the broader scheme of things.

SECTION THREE

Listed below are a number of characteristics which could be present on any job. People differ about how much they would like to have each one present in their own jobs. We are interested in learning *how much you personally believe* the average cell operator *would like* to have each characteristic present in his or her job.

Using the scale below, please indicate the *degree* to which you *believe* the average cell operator *would like* to have each characteristic present in his or her job.

NOTE: The numbers on this scale are different from those used in previous scales.

4	5	6	7	8	9	10
Would like having this only a moderate amount (or less)			Would like having this very much			Would like having this *extremely* much

____ 1. High respect and fair treatment from his or her supervisor.

____ 2. Stimulating and challenging work.

____ 3. Chances to exercise independent thought and action in his or her job.

____ 4. Great job security.

____ 5. Very friendly co-workers.

____ 6. Opportunities to learn new things from his or her work.

____ 7. High salary and good fringe benefits.

____ 8. Opportunities to be creative and imaginative in his or her work.

____ 9. Quick promotions.

____10. Opportunities for personal growth and development in his or her job.

____11. A sense of worthwhile accomplishment in his or her work.

Figure F-8. Page 4 of the RJRF instrument (reduced 35%).

EAST CAROLINA UNIVERSITY
SCHOOL OF INDUSTRY AND TECHNOLOGY
GREENVILLE, NORTH CAROLINA 27858-4353
DEPARTMENT OF MANUFACTURING

103 FLANAGAN
919 757-4705

June 15, 1990

Dear American Metalsworker:

We want your opinion very much. With Americans attempting to retain the lead in world productivity, everyone's contribution is needed. Please contribute to the solution in finding out what motivates people at work by filling out the enclosed survey form. It should only take 15 minutes of your valuable time. When finished, just fold the form and put it in the enclosed stamped return envelope and drop it in your nearest mailbox.

Your responses are confidential. No others, including us, will know how you responded as an individual. What will be learned is how metalworkers as a group are motivated. If you would like to get a summary of the results of this study, put a return address on the enclosed stamped envelope. By the way we separate the forms from the envelopes, we still will not know how you responded. We suggest you keep a separate response sheet for recording your answers by question or item number. Thus, when you get results, if you want them, you can see how you compare to the whole metalsworkers' group.

Without your response, this survey could be meaningless. Again, please fill out the survey form and return it to us by June 29, 1990. Anything postmarked after that date may not be included in the results. Thank you very much for your time and consideration.

With sincere appreciation,

A. Darryl Davis
Dean, School of Industry & Technology
East Carolina University
Greenville, NC 27858-4353

Dave Gobeski
CIM Productivity Director
East Carolina University
Greenville, NC 27858-4353

Figure F-9. The cell operator's cover letter (reduced 35%).

EAST CAROLINA UNIVERSITY
SCHOOL OF INDUSTRY AND TECHNOLOGY
GREENVILLE, NORTH CAROLINA 27858-4353
DEPARTMENT OF MANUFACTURING
103 FLANAGAN
919 757-4705

June 15, 1990

Dear Manufacturing Engineer:

We want your opinion very much. With Americans attempting to retain the lead in world productivity, everyone's contribution is needed. Please contribute to the solution in finding out what motivates people at work by filling out the enclosed survey form. It should only take 15 minutes of your valuable time. When finished, just fold the form and put it in the enclosed stamped return envelope and drop it in your nearest mailbox.

Your responses are confidential. No others, including us, will know how you responded as an individual. What will be learned is how manufacturing engineers as a group perceive the motivation of certain metalworkers as a group.

Please take note of the following descriptions:
•The person operates or runs metals machining equipment.
••The person uses a computer on the job (PLCs, microcomputers, or etc.).
•••The person uses a computer in aiding the processing of machined parts.
••••The person uses a computer in determining which parts will be machined next.
The certain metalsworkers you will be evaluating are described by all or some of the above descriptions. For the purposes of this study those workers will be referred to as cell operators.

If you would like to get a summary of the results of this study, put a return address on the enclosed stamped envelope. By the way we separate the forms from the envelopes, we still will not know how you responded. We suggest you keep a separate response sheet for recording your answers by question or item number. Thus, when you get results, if you want them, you can see how you compare to the whole manufacturing engineers' group.

Without your response, this survey could be meaningless. Again, please fill out the survey form and return it to us by June 29, 1990. Anything postmarked after that date may not be included in the results. Thank you very much for your time and consideration.

With sincere appreciation,

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Figure F-10. The manufacturing engineer's cover letter (reduced 35%).

EAST CAROLINA UNIVERSITY
SCHOOL OF INDUSTRY AND TECHNOLOGY
GREENVILLE, NORTH CAROLINA 27858-4353
DEPARTMENT OF MANUFACTURING

103 FLANAGAN
919 757-6705

June 20, 1990

Dear American Metalsworker:

A few days ago, you received a request to participate in a survey of metalsworkers. If you have not already returned the survey form (on the goldenrod paper) to me, would you please fill it out now and return it to me? I really do value your opinion and the more responses I receive, the more valuable and reliable the results are. Please return the filled-out survey form as soon as you can. Again, thank you for your time and consideration.

Sincerely,

Dave Gobeski
CIM Productivity Director
East Carolina University
Greenville, NC 27858-4353

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Figure F-11. The cell operator's follow-up letter (reduced 35%).

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DEPARTMENT OF MANUFACTURING

103 FLANAGAN
919 757-6705

June 20, 1990

Dear Manufacturing Engineer:

A few days ago, you received a request to participate in a survey of cell operators. If you have not already returned the survey form (on the goldenrod paper) to me, would you please fill it out now and return it to me? I really do value your opinion and the more responses I receive, the more valuable and reliable the results are. Please return the filled-out survey form as soon as you can. Again, thank you for your time and consideration.

Sincerely,

Dave Gobeski
CIM Productivity Director
East Carolina University
Greenville, NC 27858-4353

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Figure F-12. The manufacturing engineer's follow-up letter (reduced 35%).

APPENDIX G

SAMPLE DISTRIBUTIONS

Table G-1

Determining Representativeness of the Cell Operators' Mailing

State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed	State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed
Alabama	5	2	Missouri	10	6
Arizona	8	2	Nebraska	1	3
Arkansas	2	2	Nevada	0	2
California	74	48	N. Hamps	4	4
Colorado	8	4	N. Jersey	3	5
Connectic	18	2	N. Mexico	1	0
Delaware	2	0	New York	22	15
Florida	7	9	N. Carolin	5	7
Georgia	11	3	Ohio	39	26
Idaho	2	2	Oklahoma	5	4
Illinois	16	7	Oregon	5	3
Indiana	16	5	Pennsylva	19	20
Iowa	9	1	R. Island	0	1
Kansas	5	3	S. Carolina	4	12
Kentucky	8	1	Tennessee	10	1
Louisiana	4	0	Texas	21	14
Maine	2	4	Utah	5	1
Maryland	4	9	Vermont	2	1
Massachu	14	6	Virginia	9	6
Michigan	52	22	Washingt	9	4
Minnesota	12	7	Wisconsin	20	9
Mississipp	4	1			

$\underline{N} = 43$

Plant Site Counts ($\underline{X}$) — Cell Operator Mailing Counts ($\underline{Y}$)

$\Sigma\underline{X} = 477$ — $\Sigma\underline{Y} = 284$

$\Sigma\underline{X}^2 = 13629$ — $\Sigma\underline{Y}^2 = 5124$

$$\Sigma\underline{XY} = 7824$$

$$\underline{r} = .90;\ \underline{t} = 13.22 > 2.70\ (\underline{p} < .005,\ DOF = 41)$$

Table G-2

Determining Representativeness of the Cell Operators' Mailing without Zero Frequencies

State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed	State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed
Alabama	5	2	Mississipp	4	1
Arizona	8	2	Missouri	10	6
Arkansas	2	2	Nebraska	1	3
California	74	48	N. Hamps	4	4
Colorado	8	4	N. Jersey	3	5
Connectic	18	2	New York	22	15
Florida	7	9	N. Carolin	5	7
Georgia	11	3	Ohio	39	26
Idaho	2	2	Oklahoma	5	4
Illinois	16	7	Oregon	5	3
Indiana	16	5	Pennsylva	19	20
Iowa	9	1	S. Carolina	4	12
Kansas	5	3	Tennessee	10	1
Kentucky	8	1	Texas	21	14
Maine	2	4	Utah	5	1
Maryland	4	9	Vermont	2	1
Massachu	14	6	Virginia	9	6
Michigan	52	22	Washingt	9	4
Minnesota	12	7	Wisconsin	20	9

$N = 38$

Plant Site Counts (X)

$\Sigma X = 470$

$\Sigma X^2 = 13608$

Cell Operator Mailing Counts (Y)

$\Sigma Y = 284$

$\Sigma Y^2 = 5124$

$\Sigma XY = 7824$

$r = .89$; $t = 11.71 > 2.72$ ($p < .005$, DOF = 36)

Table G-3

Determining the representativeness of the Cell Operators' Returns

State	# of Units Mailed	# of Units Returned	State	# of Units Mailed	# of Units Returned
Alabama	2	0	Missouri	6	1
Arizona	2	2	Nebraska	3	1
Arkansas	2	0	Nevada	2	0
California	48	7	N. Hamps	4	0
Colorado	4	0	N. Jersey	5	0
Connectic	2	0	New York	15	5
Florida	9	3	N. Carolin	7	3
Georgia	3	0	Ohio	26	5
Idaho	2	0	Oklahoma	4	0
Illinois	7	2	Oregon	3	0
Indiana	5	0	Pennsylva	20	3
Iowa	1	0	R. Island	1	0
Kansas	3	2	S. Carolina	12	3
Kentucky	1	0	Tennessee	1	0
Maine	4	0	Texas	14	1
Maryland	9	1	Utah	1	0
Massachu	6	1	Vermont	1	0
Michigan	22	3	Virginia	6	1
Minnesota	7	0	Washingt	4	2
Mississipp	1	0	Wisconsin	9	0

$\underline{N} = 40$

Cell Operator Mailing Counts ($\underline{X}$) Cell Operator Return Counts ($\underline{Y}$)

$\Sigma\underline{X} = 284$ $\Sigma\underline{Y} = 46$

$\Sigma\underline{X}^2 = 5124$ $\Sigma\underline{Y}^2 = 166$

$\Sigma\underline{XY} = 827$

$\underline{r} = .84$; $\underline{t} = 9.54 > 2.71$ ($\underline{p} < .005$, DOF = 38)

Table G-4

Determining the representativeness of the Cell Operators' Returns without Zero Frequencies

State	# of Units Mailed	# of Units Returned	State	# of Units Mailed	# of Units Returned
Arizona	2	2	Nebraska	3	1
California	48	7	New York	15	5
Florida	9	3	N. Carolin	7	3
Illinois	7	2	Ohio	26	5
Kansas	3	2	Pennsylva	20	3
Maryland	9	1	S. Carolina	12	3
Massachu	6	1	Texas	14	1
Michigan	22	3	Virginia	6	1
Missouri	6	1	Washingt	4	2

$N = 18$

Cell Operator Mailing Counts (X) Cell Operator Return Counts (Y)

$\Sigma X = 219$ $\Sigma Y = 46$

$\Sigma X^2 = 4835$ $\Sigma Y^2 = 166$

$\Sigma XY = 827$

$r = .82$; $t = 5.73 > 2.92$ ($p < .005$, DOF = 16)

Table G-5

Determining Distribution Differences between the Cell Operator Mailing and Returns using the "Goodness-of-Fit" Test

State	# of Units Mailed	# of Units Returned	State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed
Alabama	41	10	Missouri		
Florida			Nebraska		
Georgia			Oklahoma		
Mississipp			Texas		
N. Carolin			Connectic	41	6
S. Carolina			Maine		
Tennessee			Maryland		
Virginia			N. Hamps		
Arizona	66	11	N. Jersey		
California			N. York		
Colorado			R. Island		
Idaho			Vermont		
Nevada			Illinois	96	14
Oregon			Indiana		
Utah			Kentucky		
Washingt			Massachu		
Arkansas	40	5	Michigan		
Iowa			Ohio		
Kansas			Pennsylva		
Minnesota			Wisconsin		

$\underline{N} = 5$

Cell Operator Mailing Counts

$\Sigma\underline{C} = 284$

Cell Operator Returns Counts

$\Sigma\underline{A} = \underline{N}_c = 46$

$$\chi^2 = 2.25 < 9.49 \text{ (DOF} = 4, \underline{p} > .05)$$

Table G-6

Determining Representativeness of the Manufacturing Engineers' Mailing

State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed	State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed
Alabama	5	0	Mississipp	4	3
Arizona	8	8	Missouri	10	3
Arkansas	2	4	Nebraska	1	2
California	74	114	N. Hamps	4	9
Colorado	8	6	N. Jersey	3	8
Connectic	18	68	N. Mexico	1	1
Delaware	2	0	New York	22	50
Florida	7	11	N. Carolin	5	6
Georgia	11	5	Ohio	39	44
Idaho	2	3	Oklahoma	5	5
Illinois	16	32	Oregon	5	1
Indiana	16	23	Pennsylva	19	26
Iowa	9	8	S. Carolina	4	3
Kansas	5	6	Tennessee	10	3
Kentucky	8	12	Texas	21	16
Louisiana	4	5	Utah	5	2
Maine	2	4	Vermont	2	7
Maryland	4	5	Virginia	9	2
Massachu	14	28	Washingt	9	3
Michigan	52	13	Wisconsin	20	31
Minnesota	12	9			

$\underline{N}$= 41

Plant Site Counts ($\underline{X}$)

$\Sigma\underline{X} = 477$

$\Sigma\underline{X}^2 = 13629$

Engineer Mailing Counts ($\underline{Y}$)

$\Sigma\underline{Y} = 589$

$\Sigma\underline{Y}^2 = 27431$

$\Sigma\underline{XY} = 16762$

$\underline{r} = .80$; $\underline{t} = 8.32 > 2.71$ ($\underline{p} < .005$, DOF = 39)

Table G-7

Determining Representativeness of the Manufacturing Engineers' Mailing without Zero Frequencies

State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed	State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed
Arizona	8	8	Missouri	10	3
Arkansas	2	4	Nebraska	1	2
California	74	114	N. Hamps	4	9
Colorado	8	6	N. Jersey	3	8
Connectic	18	68	N. Mexico	1	1
Florida	7	11	New York	22	50
Georgia	11	5	N. Carolin	5	6
Idaho	2	3	Ohio	39	44
Illinois	16	32	Oklahoma	5	5
Indiana	16	23	Oregon	5	1
Iowa	9	8	Pennsylva	19	26
Kansas	5	6	S. Carolina	4	3
Kentucky	8	12	Tennessee	10	3
Louisiana	4	5	Texas	21	16
Maine	2	4	Utah	5	2
Maryland	4	5	Vermont	2	7
Massachu	14	28	Virginia	9	2
Michigan	52	13	Washingt	9	3
Minnesota	12	9	Wisconsin	20	31
Mississipp	4	3			

$N = 39$

Plant Site Counts (X)

$\Sigma X = 470$

$\Sigma X^2 = 13600$

Engineer Mailing Counts (Y)

$\Sigma Y = 589$

$\Sigma Y^2 = 27431$

$\Sigma XY = 16762$

$r = .80$; $t = 8.11 > 2.72$ ($p < .005$, DOF = 37)

Table G-8

Determining Representativeness of the Manufacturing Engineers' Returns

State	# of Units Mailed	# of Units Returned	State	# of Units Mailed	# of Units Returned
Arizona	8	6	Missouri	3	0
Arkansas	4	1	Nebraska	2	0
California	114	20	N. Hamps	9	3
Colorado	6	3	N. Jersey	8	0
Connectic	68	8	N. Mexico	1	1
Florida	11	3	New York	50	13
Georgia	5	1	N. Carolin	6	1
Idaho	3	1	Ohio	44	9
Illinois	32	5	Oklahoma	5	2
Indiana	23	7	Oregon	1	0
Iowa	8	3	Pennsylva	26	12
Kansas	6	3	R. Island	0	1
Kentucky	12	3	S. Carolina	3	1
Louisiana	5	3	Tennessee	3	2
Maine	4	2	Texas	16	0
Maryland	5	2	Utah	2	1
Massachu	28	4	Vermont	7	4
Michigan	13	2	Virginia	2	1
Minnesota	9	2	Washingt	3	0
Mississipp	3	2	Wisconsin	31	14

N= 40

Engineer Mailing Counts (X) Engineer Returned Counts (Y)

$\Sigma X = 589$ $\Sigma Y = 146$

$\Sigma X^2 = 27431$ $\Sigma Y^2 = 1296$

$\Sigma XY = 5406$

$r = .86$; $t = 10.65 > 2.71$ ($p < .005$, DOF = 38)

Table G-9

Determining Representativeness of the Manufacturing Engineers' Returns without Zero Frequencies

State	# of Units Mailed	# of Units Returned	State	# of Units Mailed	# of Units Returned
Arizona	8	6	Michigan	13	2
Arkansas	4	1	Minnesota	9	2
California	114	20	Mississipp	3	2
Colorado	6	3	N. Hamps	9	3
Connectic	68	8	N. Mexico	1	1
Florida	11	3	New York	50	13
Georgia	5	1	N. Carolin	6	1
Idaho	3	1	Ohio	44	9
Illinois	32	5	Oklahoma	5	2
Indiana	23	7	Pennsylva	26	12
Iowa	8	3	S. Carolina	3	1
Kansas	6	3	Tennessee	3	2
Kentucky	12	3	Utah	2	1
Louisiana	5	3	Vermont	7	4
Maine	4	2	Virginia	2	1
Maryland	5	2	Wisconsin	31	14
Massachu	28	4			

$\underline{N} = 33$

Engineer Mailing Counts ($\underline{X}$) Engineer Returned Counts ($\underline{Y}$)

$\Sigma\underline{X} = 556$ $\Sigma\underline{Y} = 146$

$\Sigma\underline{X}^2 = 27088$ $\Sigma\underline{Y}^2 = 1296$

$\Sigma\underline{XY} = 5406$

$\underline{r} = .87$; $\underline{t} = 9.82 > 2.75$ ($\underline{p} < .005$, DOF = 31)

Table G-10

Determining Distribution Differences between the Manufacturing Engineers' Mailing and Returns using the "Goodness-of-Fit" Test

State	# of Units Mailed	# of Units Returned	State	# of SIC 35, 37 > 1000 Sites	# of Units Mailed
Florida	38	14	Missouri		
Georgia			Nebraska		
Louisiana			Oklahoma		
Mississipp			Texas		
N. Carolin			Connectic	151	33
S. Carolina			Maine		
Tennessee			Maryland		
Virginia			N. Hamps		
Arizona	138	32	N. Jersey		
California			N. York		
Colorado			R. Island		
Idaho			Vermont		
N. Mexico			Illinois	209	56
Oregon			Indiana		
Utah			Kentucky		
Washingt			Massachu		
Arkansas	53	11	Michigan		
Iowa			Ohio		
Kansas			Pennsylva		
Minnesota			Wisconsin		

$\underline{N} = 5$

Engineer Mailing Counts

$\Sigma \underline{C} = 589$

Engineer Returns Counts

$\Sigma \underline{A} = \underline{N}_e = 146$

$$\chi^2 = 3.58 < 9.49 \text{ (DOF} = 4, \underline{p} > .05)$$

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Publications:

Gobeski, D. L. (1990, April). Work methods analyses: Utilizing incubation schemes. Proceedings, American Society for Engineering Education Southeastern Section Meeting. pp. 165-170.

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